Ryan REPORTER

New Jet Firebee. 1
Explosive Forming. . . . 4

ROOFTOP RADAR RANGE

Vol. 20, No. 1

After flight to above 50,000 feet altitude, XQ-2C is retrieved from desert (above) by helicopter and returned to base with only minor damage. Sleek, swept-wing configuration of XQ-2C (left) gives clues to its high speed capabilities.

TARGET FOR TOMORROW

First flights of XQ-2C, advanced version of famed Ryan Firebee, are highly successful

AN advanced version of the famed Ryan Firebee remote-controlled jet target drone, designated by the Air Force XQ-2C, is currently undergoing flight tests at Holloman Air Force Missile Development Center, New Mexico.

Recent flights have been considered "particularly impressive" by Ryan flight test and design engineers. The new version of the nation's most widely used free-flight target has reached speeds in excess of 500 knots at altitudes exceeding 50,000 feet.

This performance has been gratifying because the XQ-2C has been specifically designed for high speed, high altitude flight, to perform its role as the "flying bull's-eye" for the Air Force and the Navy. As enemy aircraft fly higher and faster, so must the target drones if realistic "combat" training conditions are to be achieved by America's air defense system.

Earlier versions of the Firebee have tested the effectiveness of nearly every weapon and interceptor aircraft in the defense systems of the United States.

In one test, the Firebee was put through a flight pattern of climbs and turns to evaluate over-all handling characteristics and stability.

"The flight was highly successful," Forrest Warren, Jr., project engineer on the XQ-2C, commented after the test.

Warren said that this particular flight was terminated by fuel depletion and the Firebee was still climbing when its fuel was exhausted.

After engine shutdown the Firebee entered a controlled glide until parachute recovery was commanded. All Firebees are recovered by means of their two-stage parachute recovery systems, from water or land ranges. Parachute recovery can be commanded at any time, but it is automatic in case of a direct hit during missile firings, from fuel depletion or from loss of remote control.

As an impressive ending of this first flight, the "bird" dropped to the desert only about one-fourth of a mile from the center of a pre-determined recovery circle. It suffered such little

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Firebees are operated from this ground control station and radar plotting boord at Holloman Air Force Base. Ryan engineer Ed Sly (white shirt) uses "stick" controls while observing XQ-2C's progress on radar plotting board.

The first XQ-2C Firebee is installed under the wing of a B-26 launch plane at Holloman Air Force Base. Ryan technicians perform this job as well as the final ground check. The B-26 lifts the drone to 15,000 feet for the air launching.

damage that it could have been prepared for flight again within 24 hours, if necessary.

The XQ-2C was air-launched by a B-26 "mother" plane from under the wing. The drone's jet engine was started at 10,000 feet and the countdown to release begun as the B-26 climbed to the launching altitude of 15,000 feet. An interesting sidelight is that the "booster" thrust from the Firebee gave the B-26 a rate of climb of at least twice that of normal.

Standard engine "run time" for an operational Firebee before launch is about four or five minutes. For this test, the engine was run almost 23 minutes before release. This was to allow for a thorough pre-flight checkout. There were 26 minutes of powered flight after release and about four minutes of glide before recovery was commanded.

The XQ-2C is being developed under Air Force contract as part of a Product Improvement Program for Air Force Q-2A drones, now in production. Production of a quantity of Q-2C drones is underway. The first phase of the program calls for expenditure of $2,400,000 with the full project expected to approximate $10 million. Production will extend into 1960.

The XQ-2C is the result of many years of intensively tested improvements on the original Q-2A drone system, which has established numerous records of speed, duration, altitude and distance from ground control. It is America's most widely used jet target drone. These same Q-2A drones were the exclusive targets last year in the USAF World-Wide Weapons Meet at Tyndall Air Force Base, Florida. This was the first weapons meet to use fast, free-flying jet targets.

Aside from improved performance the basic difference between the Q-2A and the XQ-2C drone is its augmentation system. The new configuration of the drone is the direct result of a change from a "passive" augmentation system, used in the Q-2A to the "active" system used in the XQ-2C. The XQ-2C system requires more internal space and the over-all length and wing area were increased to accommodate the new equipment. Gross weight has been boosted by nearly 300 pounds. Much of this is due to the various electronic augmentation systems.

Because the Ryan XQ-2C is smaller than a full scale enemy fighter or bomber, an electronic augmentation system is used with it so that the Firebee will produce the same radar reflectivity on tracking radar and homing systems.

The Q-2A "passive" augmentation systems consist of Luneberg lenses, or corner reflectors, which reflect radar energy back in the direction from which it came, to make the drone appear larger. The disadvantages of these devices are their physical size (which generally imposes aerodynamic penalties) and their inability to provide the amount of bistatic reflection response required with semi-active homing systems.

Bistatic reflection response is the ability of a reflectivity augmentor to receive radar energy from one direction, send it back in the same direction spread out, or send it in other directions. Semi-active homing systems contain only a radar receiver and their radar energy comes from another source in a different place. An example would be a missile, with only a radar receiver, which is launched from an aircraft which supplies the necessary radar energy by beaming it to the target from which it is returned to the missile receiver.

In the XQ-2C, "active" augmentation systems replace the less effective "passive" devices, except for special target missions. The "active" systems will be airborne "traveling-wave-tube" amplifiers for radar echo augmentation.

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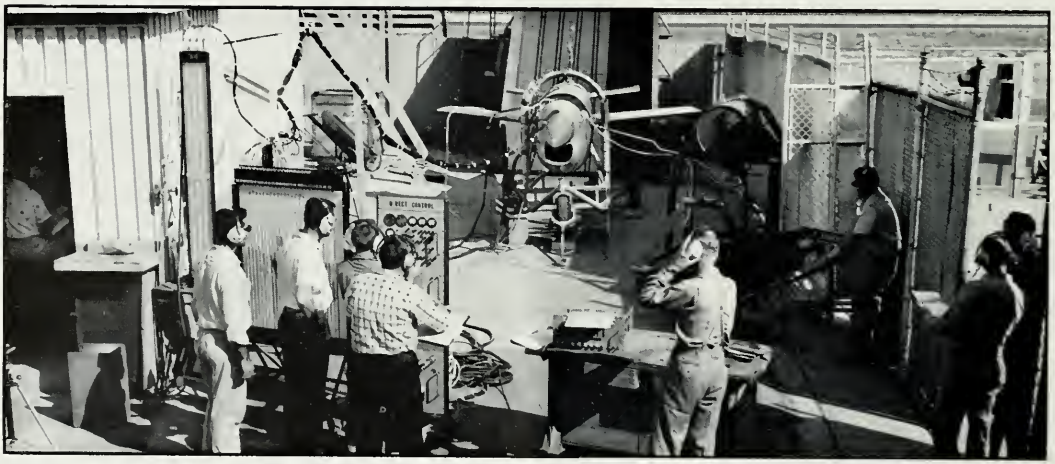

Ryan test crew gives XQ-2C final engine run-up from remote panel. Power plant is 1700-pound thrust J-69-T-29 Continental jet.

Ryan-modified aluminum router cuts steel dies at five inches per minute as employees Brecheisen (left) and Muncrief operate.

STEEL DIE CUTTER

Ryan speeds steel die cutting with router renovation

REDESIGN by Ryan tooling engineers of a swarth (changing angle) cutting machine has produced a vastly improved machine which will cut dies, used in hot forming of metal, from 24 to 50 times faster than other methods.

Stimulated by the increasing demands for steel form blocks needed by the DC-8 and Q-2A Firebee programs, Ryan engineers decided to up-grade an Orton router from its normal task of cutting aluminum form blocks.

Before the conversion of the router, steel form blocks had been produced by sawing and filing to a predetermined line, or by cutting with a three-dimensional Keller or Hydrotel milling machine. All three methods are slow, and subject to human error.

Experimental cuts convinced Ryan engineers that, with the right cutters, the Orton router could be adapted to cut steel.

Several off-the-shelf cutters were installed on the machine, but proved to be no match for the increased workload. Ted A. Grabowsky, an engineering analyst in the Industrial Engineering department, designed a new cutter for the shaper. This new design was the key to the succeeding cutter advances.

Experiments were made with different grind angles, and a progressive log was kept, which included special notations on length of life, finish of the work, and noise and safety factors.

The first cutters installed cut only two feet before

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Ryan tests new method with experimental set-up. Charge is placed in form with the die, water and metal blank.

Blast flings water twenty feet in the air as it simultaneously slams metal into die. Hard metals form easily, quickly, don't work-harden.

SPLIT-SECOND EXPLOSIV

New alloys, formed in 15 minutes by high energy method, have taken up to eight hours total time when formed by this type of impact air hammer, operated by C. E. Crist.

INCONEL, René 41, Hastelloy, 321 and 17-7 stainless steel, titanium, and some of the new "exotic" metals are becoming more and more necessary in the construction of the new generation of aircraft and space missiles. Only these tough metals can take the high temperature beating developed in aerodynamic heating and contained in the fiery blasts from rocket and jet exhausts.

But there's a price to be paid for the heat resistance and high strength of these metals. They're hard to handle and hard to form. They work-harden easily, require preheating before being stretched, require big presses and expensive dies, and most have a great deal of spring-back after forming.

To get around the fabrication problems associated with these tough alloys, Ryan has turned to "explosive forming," more accurately known as "high-energy-rate-forming." Used for some time in simple dimpling and piercing operations, and in flaring operations on cylindrical shapes, explosives are now being used to shape metal parts formerly handled on drop hammers, stretch presses, and brakes.

Ryan, with its long experience in shaping hard-to-handle metals for the aircraft industry — more than 35 such tough alloys have been put into production — recently installed a high-energy-rate-forming station, where an intensive investigation into the phenomena connected with the process is now underway.

The station consists of a pit some eight feet deep, which contains the water necessary to transmit the explo-

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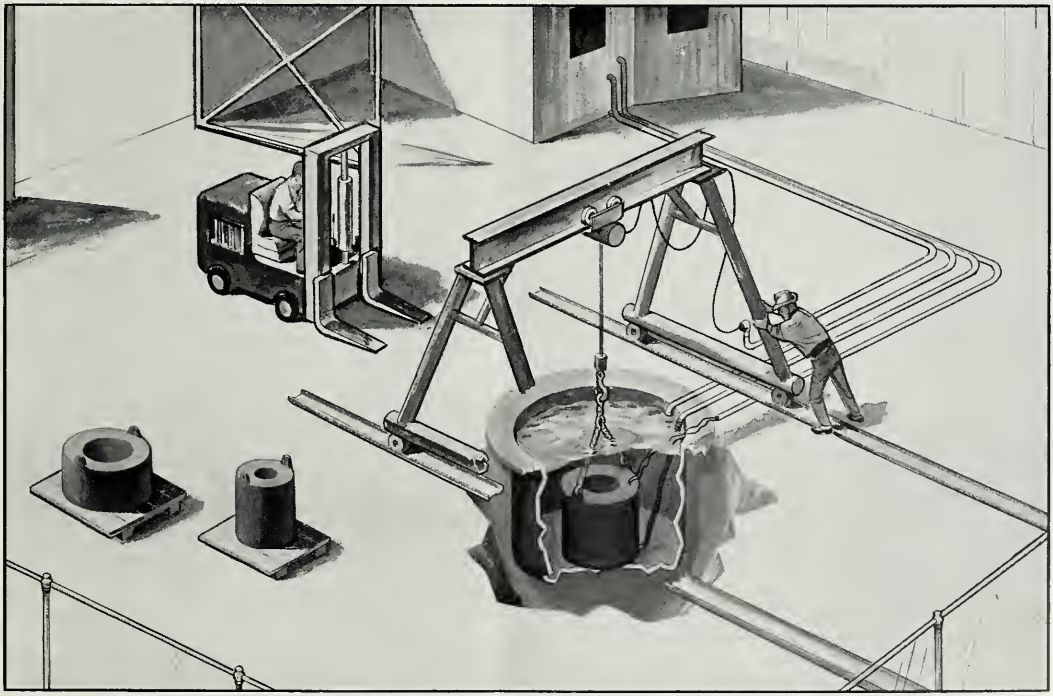
Geyser settles back to earth following forming shot. High-energy-rate method moves metal at nearly five hundred feet per second.

Pretty Ryan secretary Dorothy Pantazis holds perfectly formed bell-shaped part made from 302 stainless steel, .050-inch thick.

E FORMING

Ryan blasts tough metals to shape too fast to work-harden



Full-scale facilities, for new forming technique, are being installed in Ryan plant, as a result of success of the test program.

FIREBEE RIDES THE

New Ryan radar test range gives Firebee antennas fine tuning

YOU can spot Ryan radar radiation laboratory engineers and technicians quite easily these days. They all have good tans.

The tans are a by-product of Ryan's new Radiation Laboratory and Antenna Range which is located high on the sun-drenched rooftops of the Engineering Building overlooking sparkling San Diego harbor.

The range is new. It was developed to solve electronics problems. With the use of some old fashioned Yankee ingenuity plus extensive research the laboratory and range were completed at a very modest expenditure of money.

The future need for such a facility developed during the Product Improvement Program for the Ryan Firebee jet target drone.

The use of realistic jet-powered, free-flying Ryan Firebees, instead of slow towed targets, has marked an important advance in weapons system evaluation. These drones are capable of 600 mile-an-hour speeds and altitudes above 50,000 feet.

The ultimate target for a weapons system is the enemy. Here the Firebee makes a significant contribution. Because of its unique radar augmentation system the Firebee is a "foe of many faces." Although relatively small,

←

Firebee's radar image will be magnified due to special antennas in the quarter-scale model. Engineer Harry Bergholz directs mechanics Dixon and Middleton.

RANGE

as modern aircraft sizes go, the Firebee, with its radar augmentation system, can imitate large "enemy" bombers and other aircraft.

Firebees are fitted with electronic devices which continuously detect distances to radar-directed rockets and missiles fired at it. By means of this "intelligence" a running record of the missile approach and the "miss-distance" between missile and Firebee is instantly and accurately obtained.

To score the "miss-distance" of rockets without radar, special cameras are installed in the Firebee. Extremely fast and compact, these wide-angle-lens cameras photograph fired rockets on movie film by remote control. By measuring the image size of the rocket on the film, it is relatively simple to determine the rocket's distance from the Firebee at any time.

Firebees are also fitted with "S"-band beacons which respond to the scanning radar used by the ground control operator so that he can accurately track the Firebee's flight. To provide ground fighter control (GCI) with positive identification and location of the target, Firebees are also fitted with "L"-band radar beacons which respond to the GCI radar system. This aids ground fighter control in vectoring interceptor aircraft to sky positions for missile runs and "kills."

Ryan's need for the Radiation Laboratory and Antenna Range became apparent with the problem of positioning on the Firebee the antennas for all these electronic systems. Accordingly, Ryan radiation engineers developed and constructed the Radiation Laboratory and Antenna Range.

Ryan engineers first made surveys of several similar facilities already in operation. They studied the best fea-

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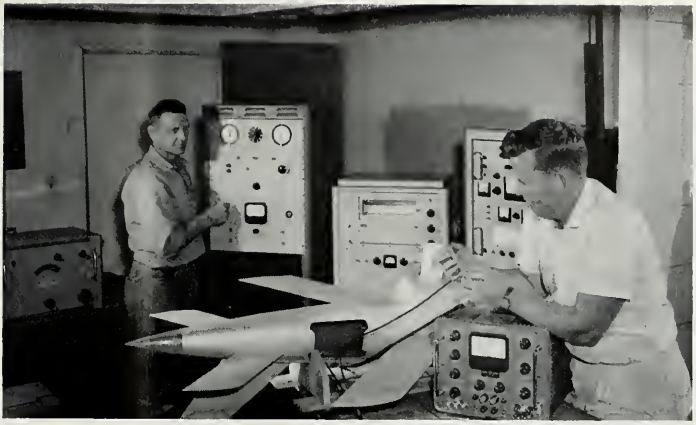


Antennas are changed in model to obtain best types and location for "enemy" simulation. Dixon, Middleton check new one.

Microwave bounce is held to minimum with Eccosorb blocks between radar and metal on roof. Bergholz, Middleton check angle.

Guidance, control, and tracking of the new Q-2C Firebees will be easier with antennas being proved out on Ryan rooftop range.

NEW JET BUILDING

Ryan puts advanced methods to work in modern new facilities to produce DC-8 jet pods and pylons

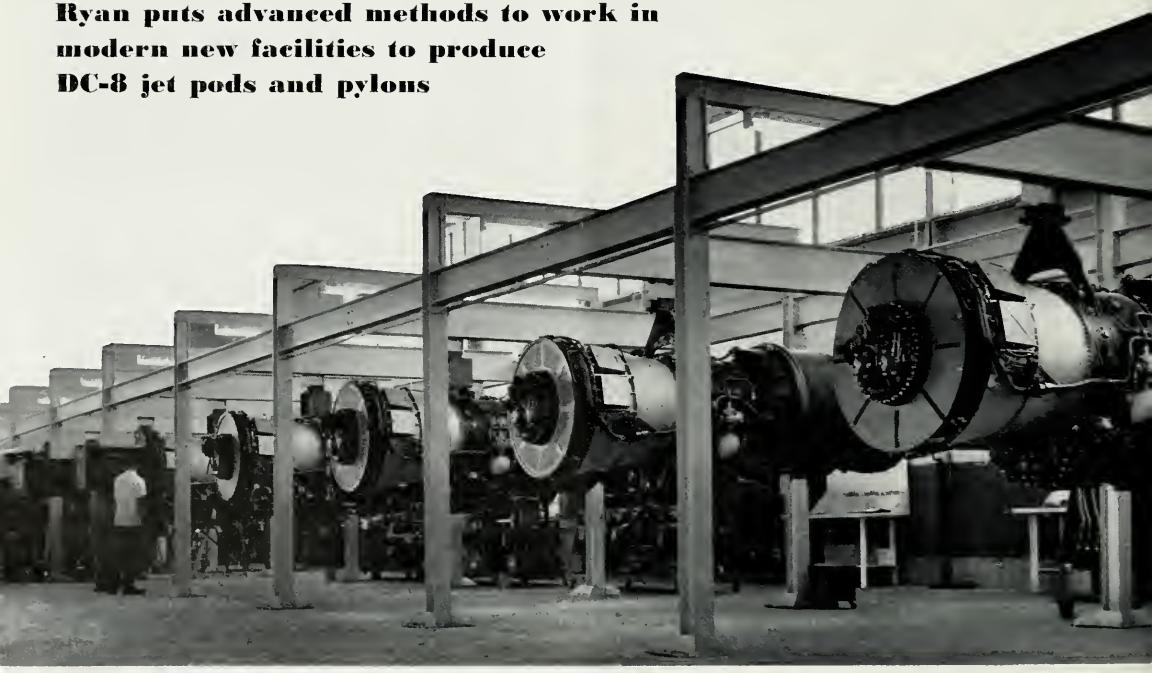
FROM a gleaming new building at Ryan's San Diego facilities roll the power packages which will hurl Douglas Aircraft Company's new DC-8 Jetliners across the skies at near-supersonic speeds. Inside the new structure, unique methods of material handling and assembly speed up the production of these power packages.

30,000 square feet in area, and costing more than $200,000, the new building is perhaps the only structure in the aircraft industry that was specifically designed to put final assembly and shipping under one roof. Every technique which would increase the flow of material through the production lines has gone into the construction of the plant, and into the design and placement of the manufacturing and assembling facilities within it.

Ryan's industrial engineers introduced new concepts in material handling, worker safety and comfort, and methods of assembly. For eye-ease, the interior of the building wears two shades of green and a ceiling of white. Glareless Koolshade glass is in the windows facing the sun. Wall studs, rather than being left exposed as in many factory buildings, have been covered with sheaths of plywood. Special air-filtering equipment, which not only adds to worker comfort, but which keeps dust to a minimum, has been installed. And, as part of this dust reduction program, aimed at preventing dust particles from reaching vital engine parts, no doors or windows open in the direction of San Diego's prevailing winds.

The new building is the final assembly area, where the thousands of feet of tubing and electrical wiring are installed in the pods and pylons; where the hundreds of components—such as the generators, starters, and fuel pumps,—which make up a complete power plant, are installed on the huge JT3 and JT4 engines; and where the engine and the nose cowl are joined.

Engine build-up, one of the most important, and highly critical, phases of the DC-8 program, received special



attention. As a result, the Ryan system of engine build-up is unique in the industry.

Ryan industrial engineers first considered, then rejected, the "traveler" system, in which an engine moves through a production line, receiving necessary parts at various work stations.

This system works well where all the power packages being built are identical. The Douglas program, however, calls for two different types of engines from Pratt and Whitney. To further compound the difficulty, each Douglas customer, even when using the same engine as another customer, requested changes in auxiliary equipment, in control systems, or perhaps in fuel line placement. Faced with these complications, Ryan turned to the "cycling" method of build-up, somewhat similar to the Air Force's "crew chief" method.

PARTS MOVE TO THE ENGINE

Rather than move the big turbojet engine past the parts, the parts are moved to the engine. The engine hangs from a stationary gantry, and is held in position by a Ryan-designed quick-disconnect which does away with the man-hours required by the conventional arrangement of shackles and nuts and bolts. A recent time test showed that the Ryan-developed quick-disconnect permitted an engine to be put in work-ready position in 24 man-minutes (three men working for eight minutes) as compared to 20 man-hours (four men working for five hours) using the conventional method.

For ease in installing parts, the engines are hung at about eye-height, since most of the components are attached below the centerline of the engine. Nine feet spacings are allowed between engines, to insure freedom of movement and easy access.

Construction of these steel I-beam gantries saved a considerable amount of money. The conventional mobile lifting and build-up dolly costs about $8,000. Ryan built the stationary gantries for about $500 each. Only one of the conventional dollies is used—

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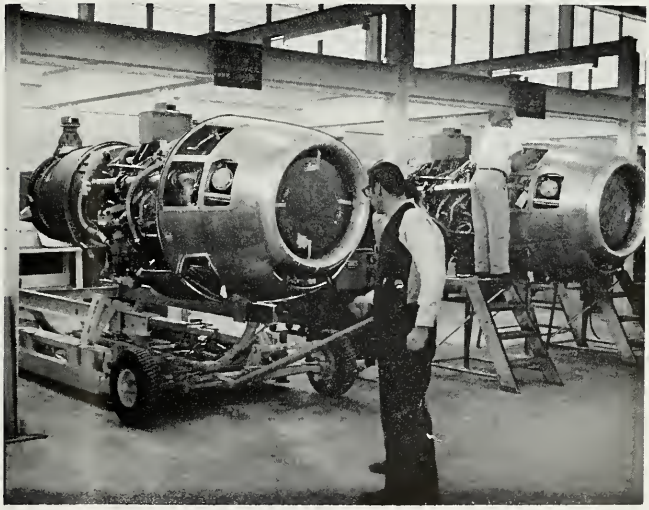
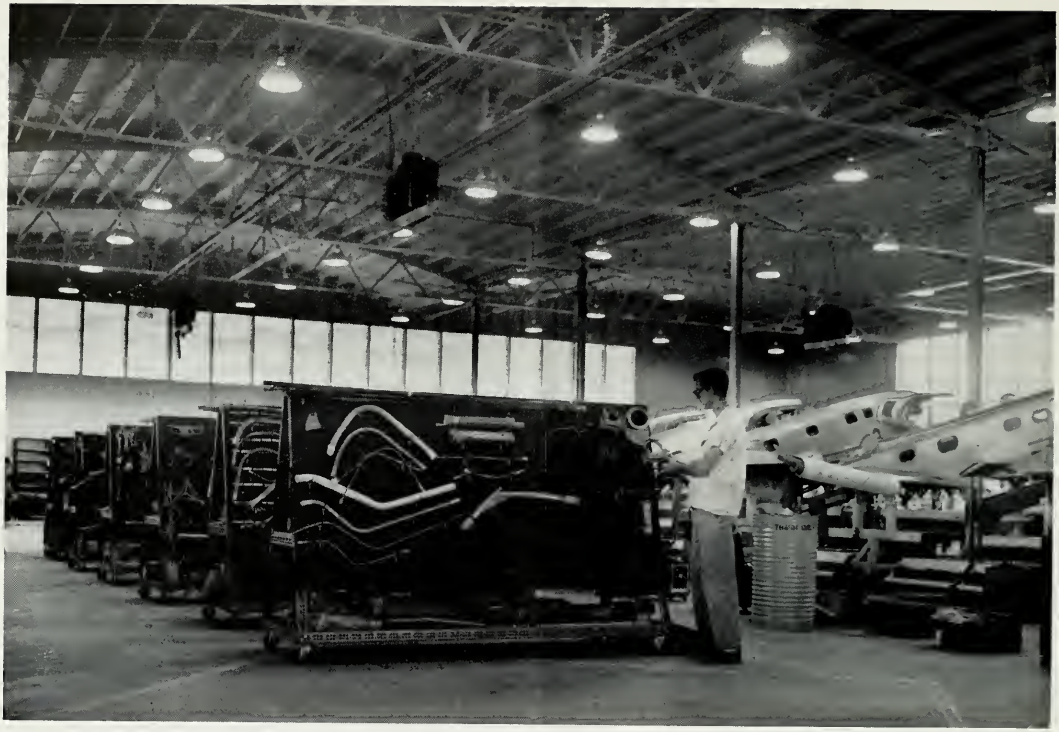
Glistening shield of nose cowl conceals highly complex anti-icing and pneumatic assemblies which contain more than 1500 separate parts of titanium, steel, and aluminum. Ryan mechanics Ed Vitela (left) and R. F. Thompson attach last pieces.

Power for the DC-8 Jetliner begins its move from the Ryan build-up station to its place on the Jetliner wing. Ryan inspector A. J. Holle gives final O.K. as service cart is wheeled into position under the Pratt & Whitney turbojet.



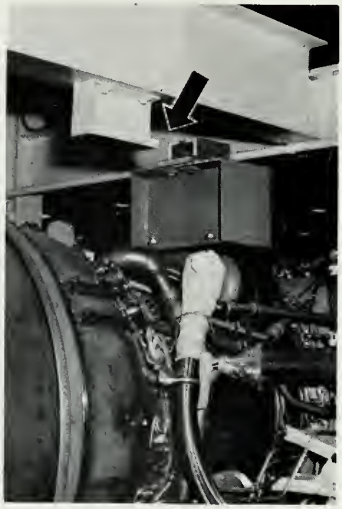


The right part for the right place at the right time is found easily from peg-board and "erector-set" A-frame by Ryan's C. E. Baggett.

to move the engines from their pressurized cans to the gantries.

"A" frames, made of 4′ by 8′ peg boards, are placed in position next to each engine. Each "A" frame holds every part necessary to complete the build-up of a jet engine; each part is taken from the board in the sequence in which it's installed; and each part —and its manner of installation—is inspected as it's put on the engine.

These frames have now been installed in each part of the pod and pylon assembly line—stub wing, pylon, nose cowl, and pod. Ryan has found that, apart from the man-hours saved, this method of build-up and inspection helps considerably in preventing the operation of Murphy's law. (Which states that if a part can possibly be installed incorrectly, someone will certainly install it that way.) Further, since many parts are interconnected during assembly, the incorrect installation of one part means the removal of several parts, with the chances being compounded that some one will put Murphy's law into operation.



DC-8 jet engines "fly" on and off gantry with aid of Ryan-designed and built quick disconnect. Device puts engine in place in minutes, saves more than 20 man-hours.

After final inspection, another unique feature of the new Ryan building is brought into play. The mobile lifting dolly removes the engine from the gantry, and the engine is then wheeled under a 5-ton capacity overhead crane. The crane hangs over a loading area in the building which is long enough and high enough to permit the engine to be loaded directly onto the trucks which will move it to the Douglas plant in Long Beach. In mere minutes the engine moves from the stationary gantry onto the special truck cradle, and the engine is on its way.

Firebee Tops New Building

RYAN'S Q-2A jet target drone, the Firebee, will long be in the eyes and minds of the citizens of Alamogordo, New Mexico.

A gleaming red and white Firebee, a retired veteran of many test missions at Holloman AFB, was recently anchored to the roof of the city's new Chamber of Commerce building.

This Firebee, with other examples of missile hardware, is a permanent display. The citizens of Alamogordo have placed these test vehicles on display as symbols of the vital link between the community and the missile, aircraft and space research conducted at nearby Holloman.

The Ryan Firebee was installed during dedication ceremonies for the new Chamber building. Also during the dedication a time capsule was sealed, scheduled to be opened in 1984. In this capsule were placed printed and pictorial records of present-day Alamogordo. Ryan's contribution for the capsule was a document outlining the company's 10 years of research and testing at Holloman, together with a prediction of Ryan's activities in 25 years.

For more than a decade Alamogordo has been "home" for a large group of Ryan engineers, technicians and mechanics. Ryan was one of the first private contractors to set up test operations at the air base, starting with the Ryan Firebird, the first air-to-air missile publicly disclosed by the Air Force.

With the completion of the Firebird testing program, a program which vaulted the art of rocketry past many technical barriers, Ryan in 1950 brought to Holloman the first Q-2 Firebee. This jet drone was destined to become the nation's most famous and widely used jet target missile.

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A bright red gleaming Q-2 Firebee drone—emblematic of the close cooperation between the Air Force Development Center and the City of Alamogordo—is hoisted to top of new Chamber of Commerce building after official presentation.

Bronze plaque from Ryan commemorates mounting of Q-2 Firebee on Alamogordo Chamber of Commerce Building. Reading the plaque are, left to right, Art Akers, of Ryan; Ray Dean, President Chamber of Commerce; Brig. Gen. Daniel E. Hooks, AFMDC Commander and Capt. C. B. Merritt, Firebee project officer at Holloman.

SPACE AGE ALLOY
Ryan harnesses a versatile new alloy --
General Electric's Rene 41 -- to the
propulsion needs of high speed flight

Space Age is marked by full range Atlas flight, Dec. 17, 1958, exactly 55 years after Wright Brothers launched manned flight.

IT'S over 50 years and some 25,000 miles an hour since Wilbur and Orville Wright first reached for the stars. The little powered kite that wobbled through the air at Kitty Hawk has metamorphosed into the giant guided missiles now probing outer space, and will eventually evolve into the space ships of tomorrow.

Metallurgical problems weren't a prime concern of the Wright brothers. Their plane was made of wood and canvas and glue, and the mechanics wire of their time. It encountered no aerodynamic heating on wing and fuselage surfaces; faced no nose-tip sublimation upon re-entry into earth's atmosphere; and the heat developed inside its engine was of no moment.

Today, the X-15 stands ready to carry man into his first explorations of outer space. Traveling at 3600 miles an hour, the skin of the rocket-powered aircraft is made of Inconel X alloy to withstand the aerodynamic heating which will make the skin glow red. Its rocket engines are made of super-alloy metals to withstand the white-hot exhaust gases that seeth in the X-15's combustion chambers.

The X-15 is the prototype — the shape of things to come. From 100 miles to millions of miles out in space is within man's reach, providing he can continue to develop metals that will carry the tremendous burdens imposed by space flight.

Heat isn't the only problem. Space metals will also have to fight oxidation and corrosion, and will have to retain strength at high temperatures. Some of the rarer metals — tungsten tantalum, molybdenum, and columbium — have melting points far above that of the strongest stainless steels, yet are of little value in these applications because of their low resistance to oxidation or corrosion. Titanium, which has an excellent strength-to-weight ratio at room temperature, loses much of its strength at temperatures of 700°F and above.

Since few of the pure metals seem to work well by themselves, why not combine them, find some modern al-

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Forerunner of manned space flight is rocket-powered X-15. Vehicle wears nickel alloy skin over a skeleton of stainless steel to withstand space's high heat and deep cold.

Westinghouse purifies a bar of Niobium metal by heating it from inside, with high frequency current, under a vacuum of four billionths of atmospheric pressure.

General Electric engineers R. E. Patsfall, L. P. Jahnke, and L. G. Wilbers, (l to r) inspect jet engine compressor rear frame, made of G. E. new wonder alloy, Rene 41.

THE air arsenal of the United States has a great many weapons, ranging in size and destructive effect from the .50 calibre machine gun to the atomic-warhead MB-1 Genie air-to-air rocket. And practically every weapon that the Air Force and the Navy possess has been hurled against the Firebee. The fleet little target drone has been shot at by 3″, 5″, and 6″ anti-aircraft guns, by deadly heat-seeking Sidewinders, by the huge Nike-Hercules, and by the Sparrow, among others. Airplanes which have chased the jet-fast Firebee include the best the nation has in operation, from the Air Force and the Navy. The world's speed and altitude king, Lockheed's F-104 Starfighter; the airplane that flashed from coast to coast in 202 minutes, the Chance Vought F8U-1 Crusader; the Falcon-carrying interceptor, the Convair F-102 Delta Dagger; and the workhorse of the second World War, the North American F-51 Mustang, have all had their crack at the Firebee. Sixteen different air defense weapons, and 17 different operational aircraft have been used in attacks on the high-flying "bull's-eye."

These planes and missiles were flung against the Firebee as part of a never-ending program designed to keep America's defense system honed to a razor-sharp edge, in response to the challenge constantly confronting us. Maj. Gen. Frank A. Bogart, Director of Plans and Programs for the USAF Air Materiel Command, has stated it:

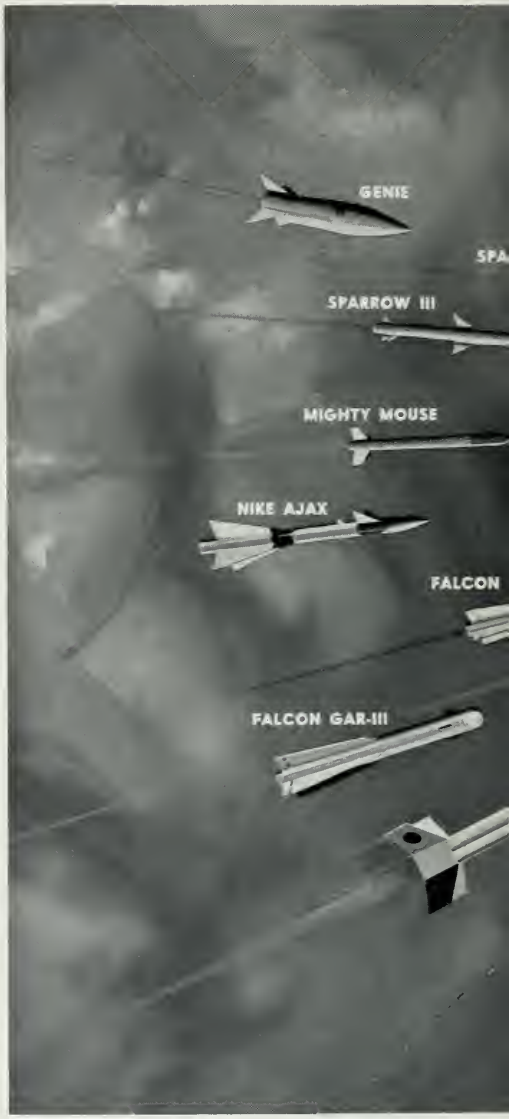
"We can no longer regard time as a military resource. The combat forces must be operationally ready at all times."

The men who man the missiles must be as sharp and ready as their machines. Only the Firebee today can provide the long range, altitude, and high speed necessary for the successful simulation of "enemy" aircraft.

Part of the preparedness program are the Annual Weapons Meets held by the Air Force and the Navy. In October, 1958, at Project William Tell, held by the Air Force at Tyndall Air Force Base, Florida, pilots fired their rockets and missiles at Firebee free-flying targets. Streaking through the air at near-sonic speeds, the Firebee made a startling contrast to the towed banner targets previously used. One pilot stated emphatically, "I'll never want to fire at a towed target again."

Small wonder. No towed target can match the Firebee for realism, can give an interceptor pilot the feeling that he's coming to grips with a "foe" which is a much greater challenge to his skills and his airplane than a canvas banner being tugged through the skies at less than half the speed of which his plane is capable.

At Tyndall, pilots flew F-102's, F-89's, F-86's, fired Falcon GAR-1's, Genie MA-1's, 2.75″ Mighty Mouse rockets. At their next annual weapons meet, the Navy will make its first use of free-flying Firebees as jet targets in this type of competition. They will send F8U-1 Crusaders, F11F-1F Super Tigers, F3H-2 Demons, and F4D-1 Skyrays up against the drones. These planes will be armed with the infrared-directed Sidewinder.



FIREBEE: AM

Ryan jet-fast target drones

RICA'S NUMBER ONE "ENEMY"

razor sharp edges on the weapons of America's air defense

Tomorrow's helicopter, kept in perfect contact with the ground with RYANAV*, could operate while fixed-wing aircraft are "socked-in."

RYAN SKY-OPENER

All-weather commercial 'copter possible with RYANAV*

RYANAV* systems would ease task of CAA traffic controllers when foul weather would otherwise stack up incoming craft.

* Trademark

THE helicopter will soon surpass fixed wing aircraft in all-weather capability.

This is the opinion Walter Gerstenberger, Chief of Dynamics for Sikorsky Aircraft, expressed in a recent London meeting of the Helicopter Society of Great Britain.

"As a matter of fact," Gerstenberger said, "commercial rotary aircraft flight could be made more dependable and profitable right now by using many of the techniques and hardware already in use with military helicopters."

He pointed out that helicopters operating on commercial routes today cannot always be flown under the same weather conditions in which fixed wing aircraft operate.

"This not only affects revenues while the helicopters are grounded," he said, "but it also has a bad effect on potential business. So there is an urgent need for an all-weather system to increase the use of the civilian helicopter to where it can compete with fixed wing airline transportation."

As an example of an all-weather helicopter, Gerstenberger discussed the Navy's Sikorsky HSS-1N, the first rotary-wing aircraft to achieve all-weather capability. This vehicle is an anti-submarine warfare helicopter capable of round-the-clock operation and is equipped with the Ryan AN/APN-97 ground velocity indicator system.

The Ryan APN-97 system is a continuous wave (CW) Doppler ground

velocity indicator which permits the Sikorsky HSS-1N to hover under all weather conditions without visual reference. Helicopter use is possible because Ryan CW Doppler systems have no low altitude limitations and can operate down to zero altitude.

Ryan CW Doppler navigators use the Doppler effect to obtain navigational data for an aircraft or helicopter in motion. This is done by transmitting radar energy from the aircraft and receiving it back as it bounces from the earth or sea. By measuring the apparent shift in frequency of the reflected waves, due to the movement of the aircraft, ground velocity can be obtained.

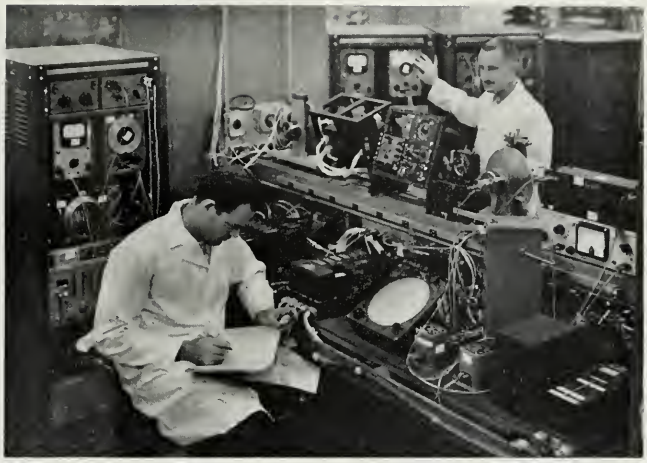
Continuous wave radar systems, such as RYANAV* navigators, can transmit and receive simultaneously and continuously from zero altitude to above 70,000 feet. Pulse type systems, on the other hand, cannot transmit and receive at the same time. At low altitudes, or below 200 to 300 feet, the transmitted pulse is reflected back so quickly that it arrives while the transmitter is operating and the receiver is shut down. The receiver then is blind to this echo wave. These dead areas of reception are called "altitude holes."

Altitude holes are not just low altitude phenomena but occur at successive higher altitudes whenever the time required for the transmitted pulse to go from the aircraft to ground and return coincides with the intervals between pulses, or multiples of them.

Also, unlike navigational equipment which depends on ground facilities or aerological data, RYANAV systems are completely self-contained within the aircraft. This feature is a requisite for global military systems and provides greater flexibility of operation to commercial users.

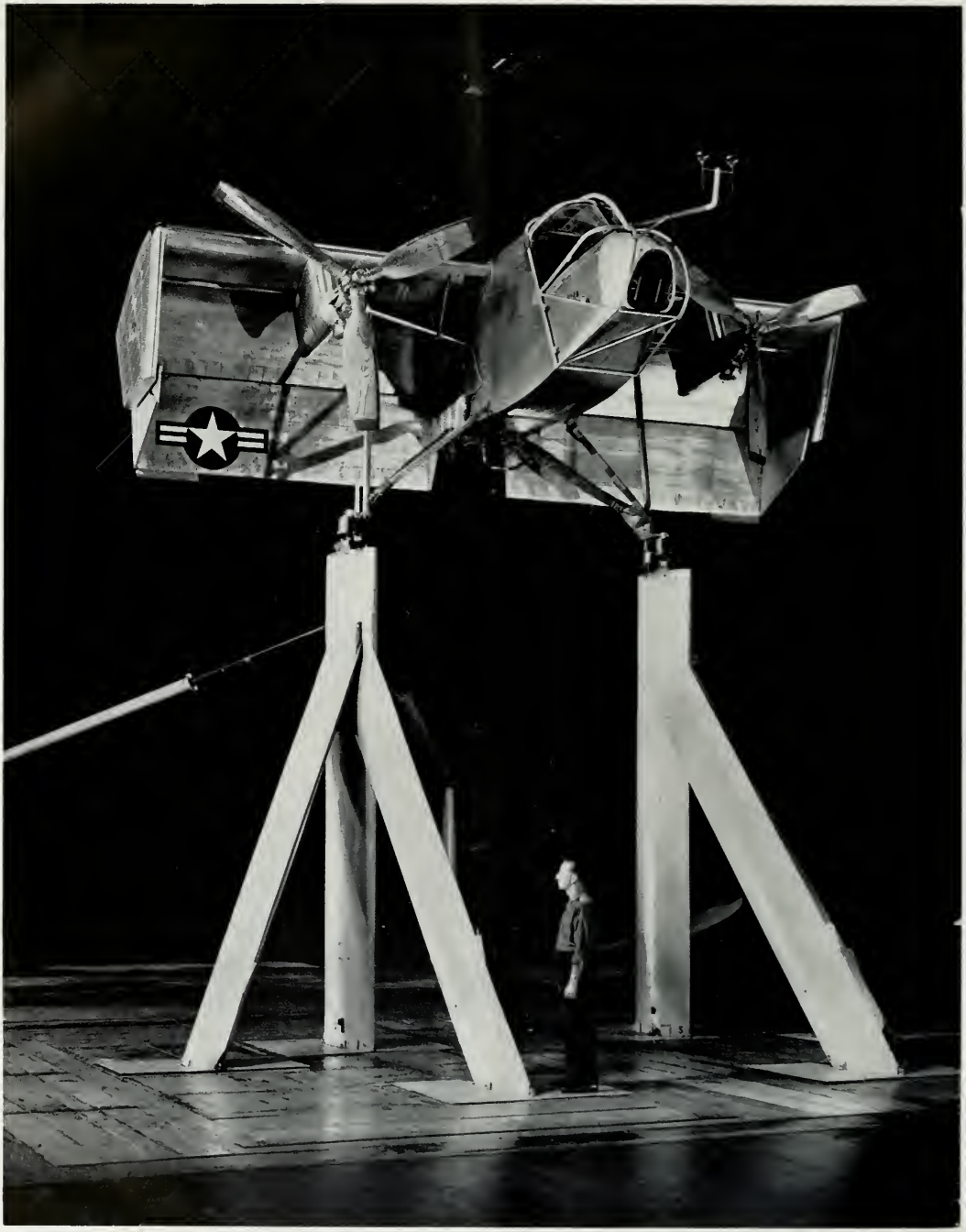
Gerstenberger pointed out in his report that although the Sikorsky HSS-1N illustrates what can be done for a particular mission—such as anti-submarine warfare—the same techniques and hardware used in this military application could be used with slight alterations to meet civilian flying problems.

(Continued on Page 25)



At Ryan's Electronics Division, Warren Norris (l.) and Robert McNaul check out a Model 120B RYANAV* automatic navigator and flight control system. The 120B is providing the U.S. Army's H-19 and H-34 helicopters with automatic navigation.

Sub-searching 'copter is given automatic stand-still capability with Ryan CW Doppler ground velocity indicator, hovering device.



Vertiplane, firmly secured to giant "stilts," braces for a hurricane of air from giant fans in Ames Research Center wind tunnel.

VERTIPLANE FLIGHT TESTED

Testing of Ryan's VTOL/STOL craft enters flight phases

NASA PHOTOGRAPHS

TESTED at altitude for the first time recently, Ryan's experimental VTOL-STOL aircraft, the Vertiplane, performed excellently through all phases of conventional take-off, flight, and landing. Ryan's Chief Test Pilot, Peter F. Girard, who also handled the X-13 Vertijet, was at the plane's controls during the test missions.

Flying at altitudes in excess of 5500 feet, at speeds up to 110 knots, the Vertiplane was tested at Moffett Field, California, where the National Aeronautics and Space Administration's Ames Research Center is located.

Girard has expressed keen enthusiasm for the Vertiplane's fine performance in all conventional flights, from

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Flight tests begin as Ryan Chief Test Pilot Peter F. Girard revs up Lycoming prop-jet. Engine, located in fuselage, spins three-bladed props on each wing, and helps control airplane through exhaust deflection devices located in tail.

Vertiplane swoops low over Moffett Field, California, during flight test. Aircraft rose to 5500 feet, flew at 110 miles per hour.

Alternating layers of adhesive and aluminum begin to take final shape as a weld ring in a high speed lathe. Ryan machinist B. A. Burgett guides tool as it bites into the ring which, when formed, has complex contours, high surface finish.

SCRAP METAL TOOLING

Glue and scrap bin salvage solves tough problem at Ryan

IMAGINATIVE engineering, coupled with close teamwork between Ryan and a supplier, recently racked up a $20,000 per year saving in tooling costs, and a considerable saving in tooling set-up time. The new development in tooling methods utilizes small pieces and scraps of tooling metal, and an adhesive developed by Narmco Resins and Coatings Company.

Material saved will amount to more than $1500, and savings on labor and salvage will run to more than $18,000. Ryan will spend only $200 annually on the new adhesive.

The new tooling method is the result of a search for tools with which to build the wing tip pods on Ryan's jet-fast target missile, the Firebee. Housed in these slim pods are the Parami scoring systems, Traid cameras, and radar reflectors which make the Firebee so efficient in its role in training the pilots of the nation's air defense system. The Parami system and the Traid camera determine the "miss-distances" of various missiles fired at the Firebee by interceptor aircraft in simulated combat firings.

About a year ago, when quantity production of the pods was first started, Ryan ran head-on into a tough production problem. The radomes of the wing pods are made of Fiberglas, and, while experimental pods had been hand formed, obviously this method couldn't be used in quantity production.

(Continued on Page 27)

High speed cuts, in any direction, came up smooth and even. No matter how tough the cut, adhesive and metal never parted.

Pull test of 4350 psi tears aluminum samples apart. Adhesion is so strong that metal gives way, adhesive stays intact.

Forest Primeval is successfully battled in effort to save downed RCAF Firebee

THERE'S a clearing in the great North woods near Cold Lake, Alberta, Canada, that may in future years be known as Sved Meadows.

This break in the impenetrable forest is the handiwork of Billy J. Sved, Ryan Technical Representative, and his Royal Canadian Air Force friends, and is the product of their undying determination to get back that which was theirs.

During a KDA-4 Firebee flight from nearby Cold Lake RCAF station, the drone made an unscheduled parachute recovery, and landed in a growth of 60-foot high trees.

Nothing daunted, the intrepid band of recovery experts, complete with axes and boundless enthusiasm, boarded an RCAF recovery helicopter and, after hovering over the recovery site, were lowered by high line to the ground to clear an area large enough for recovery operations.

Some hours and dozens of blisters later the first wild surge of ardor had worn off, and a willingness to forget the whole thing and go home was voiced by some.

Skillful, precise 'copter flying by RCAF pilot gently lifts Ryan Firebee from its "nest" in the Canadian woods near Cold Lake, where Firebee is in service.

RYAN REP GETS THE BIRD

The attitude of local command that it would be happy to recover the Firebee, and the grounded woodsmen, in that order, kept the doughty crew at it, and finally a clearing twenty-five feet across was completed.

The helicopter hovered overhead and payed out about eighty feet of cable which was fastened to the KDA-4. Thanks to the highly skilled, very precise piloting of the 'copter, the Firebee was gently eased up between the trees and away to a clearing. After depositing the bird, the helicopter returned and recovered all personnel.

Firebee and recovery experts were returned to their various maintenance and rehabilitation areas for necessary repair and reuse. Damage to the Firebee was reported to be minor.

The Firebee's disengaged parachute had drifted down onto the top of a tall tree.

To make the recovery complete, a local inhabitant was hired to chop down the tree and bring in the chute. As the tree fell with a crash, the parachute gracefully floated to the top of another tree—and another—and another.

Several days later, the main chute was delivered, with only minor repairs required to return it to service.

VERTIPLANE FLIGHT TESTED

(Continued from Page 19)

full speed down to the near zero-speed hovering condition.

On the morning of February 13, a malfunction occurred in the Vertiplane's propeller control system, which forced Girard to land with both propellers in the "flat pitch" setting. As a result, he was unable to "flare out" the airplane as it approached the runway and landed with sufficient force to cause damage to the forward portions of the aircraft.

The Vertiplane was taken to Ames Research Center for wind tunnel and flight testing several months ago, shortly after preliminary taxi testing had been concluded at Lindbergh Field in San Diego. Wind tunnel tests in the 40 by 80 foot tunnel indicated some changes in the Vertiplane, notably the addition of a ventral fin, and a change-over from tail-wheel to nose-wheel tricycle landing gear. These changes had previously been indicated by the analog computers in the Ryan engineering laboratories.

Both the Vertiplane and the Vertijet had been "flown" by the Ryan computers and flight simulators long before the actual aircraft had ever left the ground. These computers and simulators are essential tools. They allow engineers to study and predict the dynamic characteristics of an aircraft long before flight tests are made. Thus, they assist in early and rapid design considerations during the development phases.

In addition, by "flying" the simulator, the pilot is given an opportunity to learn and study these flight characteristics, and to develop handling techniques to aid him during the flight test program.

Nearly conventional in appearance and construction, the Vertiplane is a true VTOL airplane, capable of landing and take-off without ground run. Employing the deflected slipstream principle, the experimental craft has two immense flaps which extend downward from the trailing edge of the wing, giving the plane the tremendous lift needed for VTOL take-off, landing, and hovering in flight.

Slipstream on the Vertiplane is provided by two large propellers powered by a single Lycoming T-53 gas turbine engine located in the fuselage. Power is taken from the engine by shafting connected to propeller gear boxes pylon-mounted on the underside of the wing.

When the huge flaps are extended, the propeller slipstream is deflected downward, providing vertical lift for take-off, hovering, and landing. Once the plane is airborne, flaps are retracted, the plane transitions from vertical to horizontal flight and forward speed is increased.

Pete Girard, Ryan Project Engineer Fred Langraf, and Stewart Rolls, NASA Engineer in Charge of the Vertiplane project, shortly after aircraft's successful flight.

VTOL-STOL control is provided by wing spoilers for lateral control, and by variable control devices in the tail for longitudinal and directional control. These controls deflect the exhaust gases from the turbine engine

Weight-per-horsepower ratio in the Vertiplane has been held to a minimum. Part of this weight-saving lies in the use of MiniWate*, Ryan's unique approach to light-weight, high-strength, heat-resistant aircraft structures. The tailpipe of the Vertiplane, for example, is nearly 15 feet in length, yet weighs only 14 pounds. A tailpipe of conventional design and construction would have weighed more than 45 pounds.

Unlike the Vertijet, which is a tail-sitting airplane, capable in combat design of supersonic speeds, the Vertiplane rests on the ground in the normal position, and takes off vertically from a horizontal position. It has been developed in response to a need by the Army for a medium-speed liaison, reconnaissance or utility plane which could operate from rough terrain without runways. Using its propeller and wing combination for lift in vertical take-off and vertical descent and its wing for lift in horizontal flight, the Vertiplane possesses the advantages of the helicopter, yet can far exceed rotary-wing aircraft in speed and range capability.

The Vertiplane is designed for tomorrow's Army, which will fight its battles largely in the air. Not high in the air, but in "nap-of-the-earth" movements, using terrain features and forestry to dodge enemy radar and anti-aircraft fire.

Thus, in order to take advantage of the protection afforded by the terrain, the Army's combat airplanes must have vertical take-off, hovering, and landing ability, coupled with a fairly high rate of speed. In addition, they must be able to carry enough troops, ammunition and equipment to move an effective fighting force from trouble spot to trouble spot.

Such aircraft would be used as flying observation posts and artillery spotters; as troop and cargo carriers; would be used to give air mobility to ground reconnaissance; would provide command control and liaison; and would evacuate battle casualties.

In addition, the Vertiplane would be used by the Navy for Anti-Submarine Warfare and for Air-Sea Rescue efforts. Its hovering ability would make it an excellent platform for sonar search, and its speed and carrying capacity would enable it to run down and destroy enemy submarines with bombs or air-to-sea torpedoes.

*Trademark

FIREBEE TOPS NEW BUILDING

(Continued from Page 11)

It was this same Ryan drone that made the Air Force's sixth annual world-wide weapons meet — dubbed "Project William Tell"—a historic and precedent shattering affair.

For the first time, participating pilots fired missiles and rockets at jet-fast "enemy" targets, the Ryan Firebees, rather than at slow, obsolete towed targets. The Firebee's airborne electronics system made possible, also for the first time, accurate and instantaneous scoring of missile firings, and camera scoring of rockets.

The use of the Firebees in "Project William Tell" made possible the closest approach to actual combat intercept situations ever achieved in an Air Defense Weapons Meet.

TARGET FOR TOMORROW

(Continued from Page 2)

These traveling-wave-tube amplifiers are designed to provide augmentation systems compatible with Falcon GAR-1, -2, -3, -4 and -8, MB-1 Genie, Bomarc, Hawk, Talos, Nike Ajax, and Nike Hercules radar complexes. In addition, sufficient flexibility has been incorporated in the XQ-2C design to provide augmentation for future missiles with little or no modifications.

Basically, the traveling-wave-tube is a broad-band, high-gain device with the ability to detect moderately low-level signals and amplify these signals with minimum delay. These tubes do this to an average of 30 decibels above the incoming level, retaining the particular characteristics of the input signal such as frequency, pulse repetition rate, pulse width and relative amplitude.

The XQ-2C systems consist of two traveling-wave-tubes with associated power supplies, regulators, stabilizers in the amplifier package, receiving antennas and transmitting antennas. The amplifier unit is a broad-band, non-tunable device capable of responding to various radars of different signal characteristics simultaneously.

With this new augmentation system the XQ-2C Firebee has the capability of not only receiving incoming radar signals and electronically increasing their strength, but is able to re-transmit the received signal in any number of patterns including omni-directional.

The XQ-2C Firebee also contains electronic devices to report approach and miss-distance of missiles, and cameras to record missile course on film.

Other systems in the new drone may include infra-red augmentation by use of pyrotechnic flares and a smoke system to improve visual sightings.

With virtually no need for hands on the controls, this Marine helicopter recently hovered automatically at 8 feet altitude despite gusty winds of up to 30 knots velocity near Ryan Kearny Mesa plant. This performance was made possible by Ryan's new AN/APN-97 hovering detector.

Marine Helicopter Shows Capability of Ryan Device

A helicopter assigned to the U. S. Marine Corps recently demonstrated the remarkable capability of the Ryan AN/APN-97 hovering detector during a visit to the Ryan Aeronautical Company Electronics Division in San Diego.

After landing in the "backyard" of the Division's facilities on Kearny Mesa, the crew, from the Marine Air Facility at Santa Ana, showed how the hovering detector produced at Ryan enabled the helicopter to hover automatically 8 feet off the ground despite high winds, with gusts up to 30 knots.

The helicopter, one of Sikorsky's newest, is the first Marine "chopper" on the West Coast to be equipped with the Ryan device. Two others at bases elsewhere have similar equipment.

The crew came to the Ryan plant for additional indoctrination on the system, which enables pilots to hover automatically without ground or visual reference.

Several flights were made with Robert S. Sollars, Ryan field service representative, sitting in the co-pilot seat in a checkout of the hovering system.

Marine Capt. Burton, electronics officer in charge of recent flight of Marine helicopter from Santa Ana base, points out antenna for Ryan CW Doppler automatic navigation set installed in aircraft. At right is Robert S. Sollars, Ryan field service representative.

Firebee Featured in Steve Canyon

Ryan's fast, high flying target drone, the "Firebee," has auditioned and been chosen for a new role . . . a starring part in a "Steve Canyon" television show.

This TV show is presented at 8:00 p.m. Thursday nights on the NBC-TV network.

The Steve Canyon series is based on Milton Caniff's widely read comic strip about the Air Force. The show features fiction-based-on-fact yarns about exciting happenings with aircraft and missiles in the space age.

The Ryan Firebee will be featured in a forthcoming show as the "flying bull's-eye" which is used to test the pilots, planes and missiles of America's air defense system under the most realistic "combat" conditions ever achieved.

Star billing in a show is not new for a Ryan Firebee. Recently the jet drone was a headliner in Project William Tell, a precedent-setting weapons meet in which U.S. Air Defense pilots and planes intercepted and "fought" free-flying jet targets for the first time.

Dean Fredericks stars in the title role in the TV series as Caniff's dedicated Air Force pilot. A virtual double for the Canyon of the comic pages, Fredericks was selected over 150 actors who vied for the part.

Dean Fredericks, TV"s "Steve Canyon," rides "Looey" the Ryan Firebee, who will appear soon in one of his shows.

"Looey" the Firebee is suspended beneath the wing of B-26 launch plane receiving final ground checkout before going aloft for its target run.

FIREBEE RIDES THE RANGE

(Continued from Page 7)

tures of each and incorporated them into the Ryan facility.

Thanks to San Diego's almost perfect climate, the laboratory and range were built on the roof of the new Research building at a considerable saving in construction costs. When the antenna range was completed, Ryan radiation engineers began conducting Firebee antenna position tests.

They first made an exact one-quarter scale Fiberglas model of the Firebee. All of the model's parts were made from either Fiberglas or styrofoam as these materials will not reflect microwaves and bias the test results. The model's antennas, of course, were also scaled down in proportion.

As a further step towards realistic testing, the metal areas of the operational Firebee were simulated on the Fiberglas model by the use of conducting paints. Thus whatever interference the metal skin of the Firebee might have on its antennas was duplicated with the model.

Ready for testing, the model Firebee was taken to the rooftop laboratory and range. The range consists of two parallel maplewood tracks. Riding on these tracks are a model support tower and a work tower. The model support tower is made of Fiberglas and styrofoam. The top of this tower rotates so that the model Firebee may be turned along its azimuth and elevation axes during testing. The work tower is made of aluminum on which various types of transmitters and radar reflectors may be mounted.

During a typical antenna location test the model and transmitter are mounted and the towers separated to whatever distance has been specified for the test. A radar signal is transmitted to the model antenna from where it is picked up and, via cable, is graphically recorded in the nearby radiation laboratory.

Post-test analysis of the graphically recorded data reveals test results.

(Continued on Next Page)

Through such testing the best antenna locations for the Firebee are found.

Ryan finds in its new Radiation Laboratory and Antenna Range a very useful and flexible engineering facility with which Ryan engineers can perform a variety of tasks. These include; determine antenna characteristics, patterns and locations; measure the amount of reflectivity of corner reflectors and Luneberg lenses and similar devices; perform research, development and acceptance tests, and test many types of ground and airborne microwave augmentation equipment.

Some of the vital statistics of the rooftop laboratory are:

Range Track Length—206 feet

Height of Model Tower—20 feet

Height of Work Tower—16 feet

Operating Frequency of Transmitter —100 to 21,000 megacycles

Average Power of Transmitting Equipment—0.25 Watts

Operating Frequency of Receiver—30 mc to 75 kmc

Absorbing Material—410 lineal ft.

The use of this microwave absorbing material, called Eccosorb, proved to be a valuable aid in construction of the antenna range. Special emphasis was placed on reducing metal reflections on the range to a minimum. This meant that all metal materials in the immediate range area had to be removed or shielded. Many of the metal objects which ordinarily project above the roof of an industrial building were removed and replaced with Fiberglas. Anything which could not be removed was successfully shielded.

In summing up the lasting value of the new Radiation Laboratory and Antenna Range, Harry R. Bergholz, senior research engineer in charge of the laboratory, said:

"We now have at our disposal a research and development tool which takes the guesswork, or cut and try methods, out of microwave design. It provides us here at Ryan with a unit for the future, aimed at the reality of space flight communication, control and navigation."

RYAN SKY-OPENER

(Continued from Page 17)

Gerstenberger predicted that when commercial multi-engine turbine helicopters are available in the near future, the necessary automation in the cockpit to assist the pilot will be available as well.

In discussing some of the problems a helicopter pilot encounters, Gerstenberger said: "Whether you are flying a helicopter or running a business, two problems in attaining smooth operation are the philosophy of authority and the saturation of facilities."

He pointed out that although the pilot is the prime authority in directing his aircraft, he needs help so as not to saturate his mental and visual capabilities.

"It is inevitable that the pilot will become the bottleneck in the operation unless he is given help," he said.

Gerstenberger said automatic stabilization equipment (ASE) which stabilizes the aircraft without taxing the pilot with details is an example of one kind of aid for the pilot. With an ASE system certain functions of the pilot are delegated to automatic control.

This ASE equipment, Gerstenberger said, has passed all the Civil Aeronautics Authority certification tests and may be installed and used on regular airline service.

"There are no restrictions on its use," he added.

He pointed out that ASE equipment has been in operation for several years now on the Sikorsky HSS-1 helicopter. He said it has proved to be a good engineering solution to the problem of providing the pilot with a vehicle which he can handle easily and without too much dependence upon external visual cues.

"This ASE equipment has a reliability of about one malfunction in 800 flight hours and it is not improbable that this reliability can be at least doubled," he said.

Another problem in all weather helicopter operation, Gerstenberger brought out, is power plant reliability. He said a single engine helicopter must gain sufficient altitude at its takeoff point to provide a safe glide path to an emergency landing spot in case of engine failure.

"With the steep glide angle of the helicopter, operating altitudes of more than 1000 feet may be necessary over congested areas to make a safe emergency landing," he said. "It is also desirable to maintain this altitude to minimize noise complaints."

This means, Gerstenberger said, that when the ceiling is below this required safe altitude, the helicopter cannot operate under visual flight rules.

He said helicopters with more and quieter power plants will enable the helicopter airlines to operate at lower altitudes.

"This is because even with an engine failure the remaining power will maintain a less steep glide angle so the pilot may make an emergency landing from a lower minimum ceiling.

"If there is sufficient reserve power to insure level cruise flight with one engine not operating, or to insure the ability to climb over enroute obstacles, then the problem of flying with reduced visibility can be considered as the next logical step.

"Continuing the argument further, when sufficient reserve power is provided to insure hovering flight with one engine not operating, landings in congested areas during instrument flight conditions may be considered."

Gerstenberger said the gas turbine is a step toward providing this power plant. It is quieter, he said, so it will permit lower flights during visual flight conditions, and its weight/horsepower ratio is low which will allow helicopters to enjoy the required reserve power without penalizing the payload carrying ability too severely.

He said that although the expense of these capabilities might be questioned, in his opinion they should be analyzed in the light of improved safety and the additional revenue available by round-the-clock all-weather operation providing more seat miles per year.

SPLIT-SECOND EXPLOSIVE FORMING

(Continued from Page 4)

sion's force; an overhead crane which lifts the die into the water tank; and control and explosives preparation buildings. The station is located in Ryan's San Diego Plant, and the experiments have been cleared for safety by the various city, state and federal agencies concerned. In fact, as one engineer puts it, "the worst danger is from getting wet as the column of water, which is lifted about twenty feet into the air by the explosion, comes back down."

In this set-up, Ryan engineers will test several types of explosive, including dynamite, tetryl, PETN, and cyclonite. Explosives are selected on the bases of thermal sensitivity, mechanical or shock sensitivity, ease of initiation, power, and heat of explosion.

These explosives will be tested on hard metals ranging in thickness from .016 to .063 inch. The metals will be formed in spherical, conical, cylindrical, flat, corrugated, and blanking dies, made of kirksite, steel and plastic. Movement of the metal will be captured through the use of ultra-high-speed photography.

Since the process is so new, practically all of the research is being done with a view towards establishing definite parameters which would be used with various metals. Eventually, charts will be available which will indicate the exact combination to be used to obtain a certain shape in any type and thickness of metal.

Once definite parameters have been established, production line rates can be obtained in forming parts. The difference in cost between the older method of forming on presses and the new method is astounding.

For instance, Ryan is presently forming a part for a major producer of jet engines on a drop hammer. Due to the nature of the metal being used, it is necessary to hit the part several times. This causes the metal to work-harden, so that interim annealing between stages is required. These methods presently take about eight hours per part.

In a test of high energy forming, the same part was formed in fifteen minutes — from die placement, connection of detonation electrodes, explosive preparation and placement, to removal of finished part from the die. The part wasn't work-hardened, and required no annealing for final finishing.

This ease and speed in forming hard metals is the essential reason why high-energy forming is receiving major attention. While no one quite knows why these metals behave so well under high explosive forming, it is known that the metal moves into the die at speeds of from 100 to 500 feet per second, compared to velocities of 1 to 5 feet per second when using conventional methods.

There isn't any consensus as to just what does the actual forming. Some hold the opinion that the shock wave itself does the work; others believe that a gas bubble is formed in the liquid which forces the metal into the die; and others suspect that the shock wave pushes the liquid ahead of it to form the metal.

No one is quite sure, either, why there is an almost complete lack of spring-back and work-hardening. It's thought that there is a reverberatory action from the blast which has a hammering effect on the metal.

Economy, too, plays a large part in the interest in high energy forming. Present-day presses, even though powerful, cannot develop the high speeds necessary to shape hard-alloy parts. To develop presses capable of developing these high speeds would be prohibitively expensive. In contrast, the power necessary to shape large sections of high strength metal can be generated in a tank or a hole in the ground, using about twenty cents worth of high explosive, and enough water, gas, plastic or other medium capable of transferring energy from the explosion to the blank being formed.

High energy forming develops tremendous power as well as speed. TNT generates a pressure of 690,000 pounds per square inch; nitroglycerin develops 1,200,000 psi; and a relatively "low powered" explosive such as 30% ammonia gel produces 490,000 psi. These pressures are developed practically instantaneously and are transmitted in milliseconds to all parts of the blank of metal being formed.

At Ryan, various shapes have been easily formed. Hemispheres, bell shapes, corrugations, and deep draws have been successfully achieved. Using PETN, which is a blanket type of explosive somewhat resembling linoleum, a single blank has been formed into two different side-by-side shapes of different depths.

Ryan engineers feel that there is practically no limit to the variety of shapes and types of metal that can be formed with high-energy methods. Close tolerances in low-carbon steels, aluminum, brass and copper, as well as the hard alloys can be obtained, and intricate shapes seem to pose little problem.

Admiral Sanders Named Advisor at Electronics

Rear Adm. Eddie R. Sanders, USN (Ret.), a naval aviator with long experience in command duty, has joined the Ryan Electronics Division as executive advisor to Owen Olds, Director of Engineering and Customer Relations, on matters pertaining to military relations.

Adm. Sanders

Sanders studied electrical engineering at the University of Illinois, and graduated from the U. S. Naval Academy in 1930. He attended the Naval War College and received his wings after completing flight training at the Pensacola Naval Air Station.

His wide variety of aviation and shipboard experience included command of the escort carrier Cape Esperance and the attack carrier Hancock, duty as Chief of Staff, Operational Development Force, Atlantic Fleet; Deputy Director, Air Warfare Division, Office of Chief of Naval Operations, and commanding officer of Grosse Isle, Mich. Naval Air Station.

His early military experience included command of Bombing Squadron 137 of the Pacific Fleet. Early in World War II, Adm. Sanders was a flight test pilot on duty at the Naval Air Station in Anacostia, District of Columbia.

SCRAP-METAL TOOLING

(Continued from Page 20)

Search for a male mold on which to cast the radomes was started. The search turned up the distressing fact that an aluminum casting and pattern would take more than six weeks for delivery.

As an alternative to the aluminum pattern and casting, Ryan industrial engineers conceived the idea of building up the tooling mold in a manner similar to the pattern making procedure of gluing wood blocks together to build up a form block. However, instead of wood blocks, scrap pieces of cast aluminum tooling, metal bonded together with a structural adhesive, would be used.

Structural adhesive samples were obtained from Narmco and a series of tests were started. Within ten days, Ryan engineers had not only a workable mold but had produced the first Firebee radome.

The success of this initial venture into plastic tooling led to further experiments. The use of scrap pieces of expensive cast aluminum tooling metal was promptly expanded. Instead of purchasing new metal for forming blocks, jigs, mandrels and similar tools, Ryan had scrap and small pieces of tooling metal rough-sawn and bonded with adhesive to form blocks of required sizes. These blocks were then machined to the desired size and configuration to meet tooling needs.

As Ryan engineer Ted A. Grabowsky, pointed out, "Not only did we save on labor and material costs, we were also able to produce a tool superior to that possible under previous salvage methods."

Previously tools had been made by building up blocks, using pieces and scraps of tool metal and fastening the pieces together with dowel pins and bolts. Awkward and time-consuming, this method necessitated the plugging of dowel and bolt holes to prevent the scarring of new material whenever the blocks were used.

When tools are built with the new adhesive method, Ryan engineers prepare the metal with a methyl-ethyl-ketone wipe, an alkali cleaning for ten minutes, a five-minute hot water rinse, vapor blast and two-minute water rinsing, followed by ten minutes of air drying. This is followed by a 15-minute, circulating oven dry at 200°F, after which pieces are permitted to air dry at room temperatures for 60 minutes, and then allowed to cool to room temperature.

Narmco's Metlbond tape is then inserted between the primed faying surfaces and subjected to a cure cycle of 350°F at 100 psi for 60 minutes.

Adhesion is so strong that, regardless of the severity of cut during machining operations, the bond has never been torn apart. In pull tests, the metal, rather than the adhesive, has given way in some places.

Ryan success with the new tooling method has caused the company to turn to other experiments in the use of structural adhesives in the development of inexpensive tooling.

Firebee Sets Navy Target Record

All records for endurance and altitude by production Navy jet target aircraft were broken by a Ryan KDA-4 Firebee in a recent flight at the Naval Missile Center, Point Mugu, Cal.

The KDA-4, latest production model of the famed 500-mile-an-hour remote-controlled target, attained an altitude in excess of 48,000 feet and remained in the air one hour, 18 minutes, all but seven minutes of which was powered flight. This target was powered by a Fairchild J44 turbojet engine.

On fuel depletion, the target glided to 14,000 feet, where parachute recovery into the ocean was commanded by the remote controller. The target was retrieved from the sea and a third parachute decal was added to its fuselage, indicating its third successful mission. Individual Firebees have made as many as 19 flights in constant reuse as targets.

Further indicative of the KDA-4's high-altitude capabilities in providing realistic evaluation of air defense weapons systems was another feature of the record-breaking flight — 53 minutes at an altitude above 40,000 feet.

Ryan KDA-4 Firebee which recently set new Navy jet target altitude and duration record is shown suspended from launch plane at Pt. Mugu, Cal. Naval Missile Center. Left to right, Comdr. R. C. Thatcher, Division Officer of Missile Test Unit III, which flew the mission for production evaluation; E. J. Luck, Deputy Division Officer; Lt. Comdr. R. B. Schabaker, KDA Project Officer and launch plane pilot; Marine Capt. R. Sheppe, chase plane pilot; W. C. Slowey, remote control pilot; R. A. York, KDA Project Engineer; M. E. Juberg, Ryan field representative; and W. A. Collins, representative of Fairchild Engine Division, builders of the Firebee's J-44 jet engine.

T. Claude Ryan, company President, at right, receives the San Diego Kiwanis Club's "Community Builder Award" citation from Dr. Herbert C. Peiffer, Jr., Dean of Students, San Diego State College.

WINS COMMUNITY AWARD

T. Claude Ryan, company President, has been presented a Builders' Award by the Kiwanis Club of San Diego in recognition of his "many and varied contributions to the building of our community." The accompanying citation read:

"Starting with a surplus military airplane in 1922, Ryan built planes for the first contract air mail service and flew survey flights for the first west coast airline. He built the company which built the "Spirit of St. Louis," in which Lindbergh spanned the ocean; trained military pilots, and helped to build democracy's air armada of World War II.

"He built the great aircraft company which bears his name today, and accomplished in the Ryan Vertijet one of the most significant technical break-throughs in aeronautical history.

"As he built his company and pioneered a new industry in San Diego, Ryan, by his many never-publicized contributions to youth organizations and activities, never ceased to also help to build a better community."

STEEL DIE CUTTER

(Continued from Page 3)

giving way, but continuing design improvement produced a cutter that would cut 40 feet without resharpening.

Eleven different grades and makes of carbide cutter tips were tried before Firth Sterling Corporation came up with special tips for the machine. These tips save appreciable grind time and diamond wheel wear.

Satisfied with the design and availability of the new cutters, the Ryan tooling department made a complete set of tools to produce them. The cutter grinding department developed a brazing jig for brazing the carbide tips to the cutter shanks.

Since safety is of prime importance, each cutter is magnafluxed after each use to insure against cracks in the tips or shanks.

As the cutters were put to use, machine weaknesses were noted. The Thurston chucks frequently broke in the shank. The redesigners took the task in hand and built chucks with ten times the life of their predecessors.

The basic machine was completely rebuilt by replacing all studs with hardened studs and nuts. The ways were tightened and wipers were added. The old motor was replaced with a totally enclosed, statically and dynamically balanced motor.

K. L. Conley, department foreman, added a redesign of the winch used for pulling blocks through the machine. The winch design eliminated the need for a third operator.

A new oil mist coolant system was designed to give quick and adequate cooling.

Last touch to the redesign was added in February, 1959, when a new heavy duty spindle was installed by the Orton company.

Since its redesign, the router has cut over five miles of cold rolled steel and high temperature meehanite cast iron. Production records prove the machine can produce a swarth cut 50 times faster than can be done by hand, 30 times faster than a three-dimensional cut with a Keller, and 24 times faster than a three-dimensional cut with a Hydrotel.

On the Orton router, prior to cutting, a template is fastened to the top of the block with screws. The block and template are then placed on the work table, the template resting against the router's stationary guide. The block is then manually pushed by one operator past the cutter which is revolving at ten thousand rpm. The cutter cuts aluminum at a rapid rate, as much as .060 inches deep and at a feed rate of up to ten inches per minute and cuts steel at .020 inches in depth and at a feed rate of 5 inches per minute. The changing angle cut on the block's edge, or swarth cutting, is accomplished by a second man operating a hand wheel which tilts the entire spindle assembly around the top edge of the block, referred to as the point of tilt or inside mold line.

The original Orton router was installed several years ago, one of the first on the West Coast. The router, more properly termed a variable tilt shaper, saved the company thousands of dollars in manhours. It cut seven-eighths of the machine time required to cut cast aluminum alloy forms for hydropress use.

Before the machine was moved in, the aluminum forms and the harder steel ones were made almost by hand.

First, the slab was cut out with a Tannewitz band saw, using a steel template in the case of the aluminum block and following a scribe line in the case of the steel block. Then the block was filed by hand to the contours desired.

(Continued on Next Page)

Since the blocks were usually two inches or more thick, and the edge contour demands changed frequently, the process needed to be checked and rechecked constantly. Accuracy of the work depended on the skill of the mechanic. In addition, it took several days to complete one block.

Redesign of the router has been so successful that the Orton Company is planning a new model to include some thirty-two modifications made by Ryan to the router already on the plant floor in the tooling department.

SPACE AGE ALLOY

(Continued from Page 13)

chemist's formula which would utilize the best properties of each in one super-alloy?

Ryan, who first became acquainted with the super-alloys while designing and building exhaust systems for most of the nation's piston engined transport aircraft, has wrestled with nearly every super-alloy yet devised by the country's metal makers. For instance, Ryan introduced the aircraft industry to 18-10 and 19-9DL stainless steels, and is today machining, forming, and testing many of the new super-alloys in the company's metallurgical laboratory.

One of the latest of the super-alloys is General Electric's René 41, now being made by many steel producers. René 41 is being used on production parts in the Ryan plant, and Ryan engineers are enthusiastic about the promise of the new alloy.

René 41 is a nickel base alloy, with high amounts of cobalt, chromium, and molybdenum. Titanium, aluminum, and iron make up the balance, with slight amounts of carbon, silicon, manganese, and boron. René 41 is a vacuum-melt alloy, which can be obtained in sheets up to 48″ wide x 120″ long, in thicknesses down to .010″. Bar stock is available up to 3″ in diameter, and foil down to .001″ in thickness. A fine-wire form is also available, which is just .0015″ in diameter — half the thickness of a human hair.

René 41 is a very high strength, heat and oxidation resistant alloy. At 1000°F, it has an ultimate tensile strength of 180,000 psi, and at 1800°F it still retains an ultimate tensile strength of nearly 40,000 psi. Yield strength at 1000°F is about 135,000 psi, still holding almost 40,000 psi at 1800°F.

René 41 obtains its tremendous strength through a precipitation hardening process, which is accomplished in two steps. The material is first heated to 1975°F for 30 to 60 minutes, air cooled and then reheated to 1650°F for 4 hours, and then air cooled again. The first heat treatment is a resolution process, and the second heat treatment is the aging process.

Like many of the super-alloys, René 41 will work-harden, and annealing will be necessary. This can be done by heating the metal to 1975°F for 30 minutes, and then quenching quickly in oil or water. Oil is preferred to water, since less distortion will result.

Quenching must be completed in 2 seconds to obtain ductility. Air cooled material has a Rockwell hardness of C-30 with 31 per cent elongation in 2 inches, while quick quenched material has a Rockwell hardness of C-23 or less with elongation increased to 45 per cent.

René 41 presents few problems in welding. Like most alloys, welding surfaces must be clean, and the use of copper back-up chill bars or water cooled welding fixtures is desirable. It should be welded when the material is in the annealed or slightly cold worked condition. René 41 is, however, extremely "splash" sensitive, so that good fitting faying surfaces are essential.

René 41 has a somewhat greater resistance to forming than the other nickel alloys, such as 18-8. All forming must be done in the annealed condition. In this condition, it is quite ductile and forms readily on the drop hammer, expanding mandrel, stretch former, and on class "A" dies on the punch press. Ryan has very successfully formed production parts from René 41 using high-energy-rate forming. The metal formed without spring back, and hardened only two points on the Rockwell "C" scale.

The new alloy cannot be cut on all saws. Do-All and other slow speed saws are entirely inadequate. It can be cut on Tannewitz or other high speed saws which cut by a friction process.

Shearing is less of a problem and can be done at room temperature with either square or rotary shears. It is not necessary to remove areas adjacent to the sheared edge prior to welding as is sometimes the case with other super-alloys.

Punching and drilling must be used to obtain circular openings, since a hole saw is highly unsatisfactory. Drilling may be done in either the annealed or aged condition without difficulty.

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ON THE COVER

Rooftop radar range "riders," Albert Dixon (bottom) and Thurston Middleton, position radar dish in front of quarter-scale model of Q2-C Firebee in this photograph taken by Dave Koser.

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Ryan Firebee

jet drone missiles

are flying longer, farther, higher, faster on target missions—and more of them "live" to fly another day.

For example, at Vincent Air Force Base recently, the 4750th Drone Squadron launched 44 Firebees *in a row*, which averaged one hour's flight duration each. And 39 of them—many after target "hits"—were recovered successfully for re-use!

Other Firebee firsts: the one that completed 19 missions; the one that flew 1 hour, 42½ minutes; the one that made a flight 152 miles away from ground control and returned to be recovered in a pre-selected area; the drones that regularly fly target missions at Mach .9; and the *production* "birds" that have flown above 50,000 feet.

An elusive, pilotless plane, the Ryan Firebee is the most widely used jet target in training operations . . . the most realistic stand-in for "enemy" aircraft. That's why the Firebee is used as the target for such weapons as the Air Force Falcon and Genie; Navy Sidewinder, Sparrow, and Terrier; and Army Nike. That's why the Firebee was the exclusive target drone used in the Air Force's recent Project William Tell to evaluate the combat readiness of America's air defense system.

Ryan Aeronautical Company, San Diego, Calif.

Ryan REPORTER

Gravity Propulsion 1
Fast-Frozen Metal 12

100 MILE CANNON

Vol. 20, No. 2

FLIGHT BY GRAVITY

Ryan engineer sees gravity as a motivating force in space travel

"In nature's infinite book of secrecy a little I can read."
William Shakespeare,
Antony and Cleopatra

ONE of nature's best kept secrets has been the cause of gravity. From ancient Egypt to today, man has speculated on how the stars whirled in their orbits. When it was finally accepted that the earth was not flat and was not the center of the universe, man turned his speculative powers to why he clings to the face of his planet as it spins through space at 67,000 miles an hour.

One of the greatest of those who thought on this problem was Sir Isaac Newton, who, so the fable goes, evolved his Principia Mathematica—the laws of nature's mechanics —after he was struck on the head by a falling apple. Newton's laws, even though they did not explain the basic cause of gravity, were adequate for his time, and for a long time after. Until better means of exploring the heavens, and charting the courses of the stars and planets had been developed, Newton's theories sufficed.

New and deeper investigations into the laws of the universe began when astronomers found that Newton's laws could not explain the anomalous perihelion movement of Mercury, in which the apsidal line of Mercury's orbit shifts for an angular displacement of forty-one seconds in a century, in excess of the predicted value of 5,557 seconds of arc per century.

Near the turn of the nineteenth century, Albert Einstein demolished a great many of the theories which had gone before him, when he published his Theory of Special Relativity. Among the concepts which he seemingly swept away was the concept of ether, a medium which, to previous philosophers, permeated the universe and permitted the propagation of light waves.

We say "seemingly." Since the publication of the treatise on special relativity, experiments have taken place which indicate that a review of the concept of ether may be of help in determining a valid postulate of gravitation.

One of these experiments took place in 1925 at Clearing, Illinois, under the sponsorship of the University of Chicago. A pipe line one mile long and 12 inches in diameter was laid on the ground in the form of a rectangle 2010 feet by 1113 feet. Air was then exhausted from the pipe. Light from a carbon arc was divided at one corner by a thinly coated mirror into direct and reflected beams, which were reflected around the rectangle by mirrors at the corners. The two beams returning to the original mirror produced interference fringes, due to the retardation of the beam traversing the rectangle in a counter-clock-wise direction. The observed displacement was found to be 0.230 ± 0.005 of the fringe width, agreeing with the computed value of 0.236 ± 0.002 — within the limits of experimental error.

The experiment was devised to test the effect of the earth's rotation on the velocity of light. The expression for the difference in path between two interfering beams

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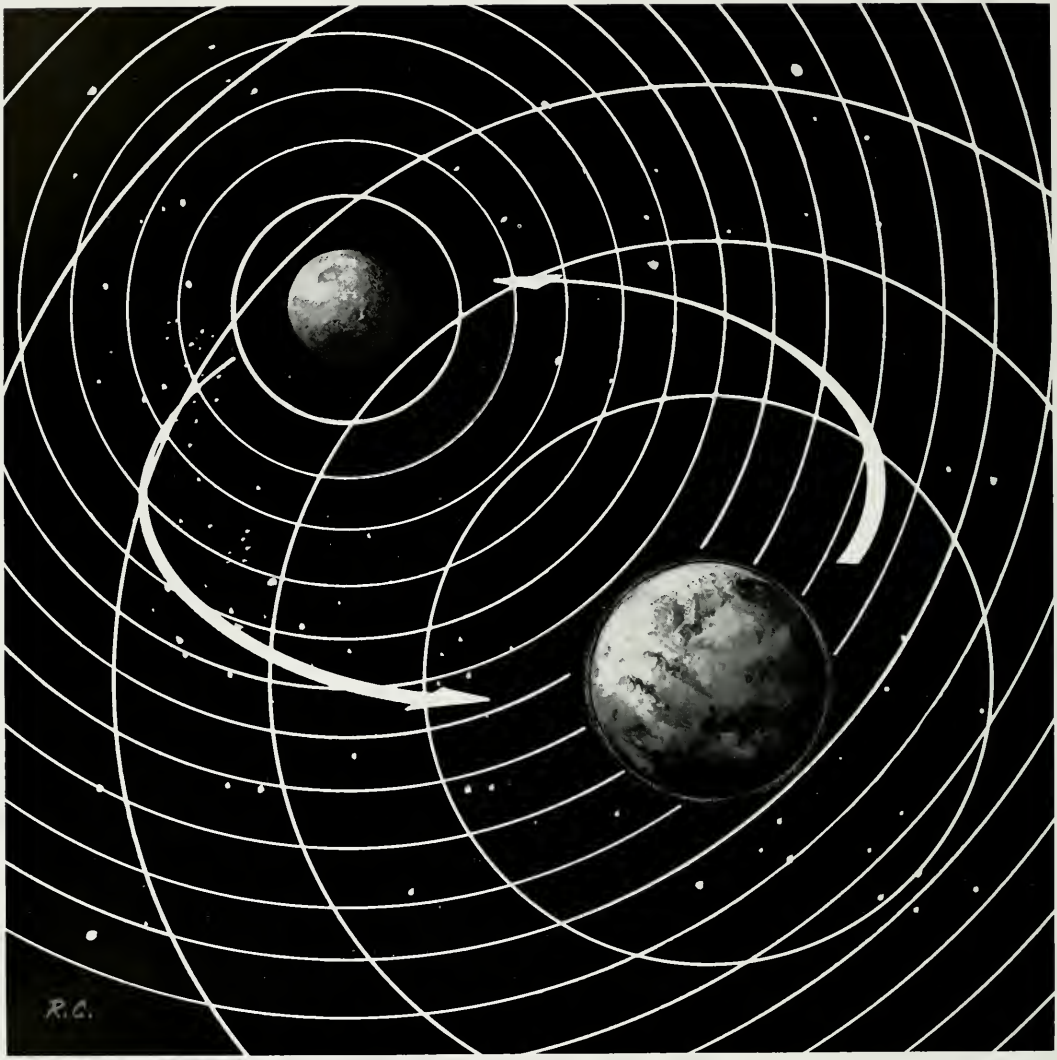
SAN DIEGO TRIBUNE PHOTO

Ryan Engineer Vjekaslav Gradecak outlines the fields of gravitational force which interact between the earth and the moon.



Pulsations of masses in the universe are in harmony with basic pulsation, and are propagated throughout universe with finite speed.

of light, one of which travels in a clockwise, and the other in a counter-clockwise direction, may be deduced on the hypotheses of a fixed ether.

The English physicist, Sir Oliver Lodge, had this to say about the clash of concepts between relativity and ether:

"Einstein's law of the composition of velocities is not a purely kinematic relationship between geometric points moving in a mathematical abstraction called empty space, but a dynamical relation of physical bodies moving within a universal medium called ether. Since the characteristic propagation of light, c, enters into the functional relationship describing the motion of bodies, it is obvious that the ether is involved; and, the sole reason for the speed of light entering into the equation of velocities of two physical bodies is required by the universal medium within which they move. If it were only a question of relative velocities of the two bodies in perfect emptiness, devoid of any physical attributes whatsoever, then the introduction of any third velocity, c, would be irrelevant and meaningless. Therefore, the view that Einstein's theory eliminates the ether is

contradictory to the theory because such a view denies what the theory affirms, namely ether under the disguise of light velocity."

Since it seemed obvious to some that light required a medium in which to travel, it was thought that if speed of the propagation of gravity were found to be equal to the speed of light, then the existence of a medium (ether), common to both, would be firmly established.

In an attempt to establish the speed of the propagation of gravity, Paul Gerber, in 1898, re-examined the problem of the perihelial motion of Mercury. Gerber found that the propagation velocity of gravitation was about 190,000 miles per second, which closely approximates the speed of light, 186,000 miles per second.

Einstein had attacked the same problem in his Theory of General Relativity. It is important to note that Gerber's formula is identical to Einstein's.

Gerber: $c^2 = \frac{24\pi^3 a^2}{x(1 - e^2)T^2}$ = **propagation velocity of gravitation**

Einstein: $x = \frac{24\pi^3 a^2}{c^2 (1 - e^2)T^2}$ = **anomalous perihelion shift of any planet**

The views of Sir Oliver Lodge offer a good reason why Einstein's relativistic and Gerber's non-relativistic theories furnish identical results. It is simply due to the fact that both theories are based on the assumption of ether, contained in Einstein's theory implicitly, and in Gerber's explicitly.

Another example of how relativistic and non-relativistic theories can be in essential agreement on a rather fundamental question is provided by a paper published one year prior to the publication of Einstein's Theory of Special Relativity. This paper concerns itself with the theory of radiation of bodies in motion, and the final equation

$$E = \frac{3}{8} mc^2$$

as given by the author, F. Hasenoehrl, demonstrates the equivalence of mass and energy in a way which differs from the famous Einstein equation by a factor of only three-eighths. The essential relationship, however, of energy, mass, and light velocity is the same in both equations.

Newton's laws of celestial mechanics imply instantaneous gravitational action. Gerber's theory—which has since been confirmed by astronomical observations—states that the velocity of gravitational propagation is equal to the speed of light.

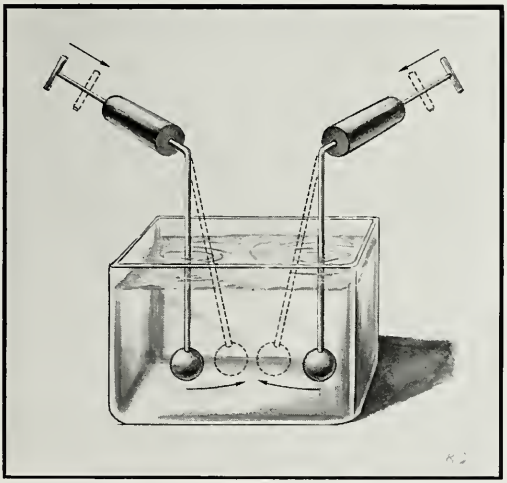
Thus, gravitation propagates with finite speed, and in its omnidirectional radiation, it suffers absorption of energy due to the intervening medium, or ether, or physical space, since we know of no physical process that, left to itself, could go on indefinitely without any damping, or slowing down.

Only a mathematical definition of space as a perfect vacuum provides the possibility of disregarding the physical attributes of space. It stands to reason, therefore, that someone should have tried to devise an experiment for testing the hypothesis of gravitational absorption.

Someone did. In 1920, in Italy, Q. Majorana measured a loss of weight of a leaden ball shrouded by mercury, and computed from the observations that there was indeed a measurable amount of gravitational absorption.

Is there, then, an all-comprehensive theory which could possibly be used as a postulate of the basic cause of gravity?

If we admit that Gerber has established that gravity moves through the universe at the speed of light, and that, like any other physical process, it must have a medium through which to move, then a review of Arthur Korn's theory of gravity, based on his treatise, "The Problem of Universal Vibrations Propagated Through a Universal Continuum Able to Absorb Energy," may be useful.



1895 experiment with rubber balls, pumps and tank of water demonstrated attraction through pulsation. Balls moved together when pulsations were in phase, moved apart when out of phase.

Several years before Korn published his paper, C. A. Bjerknes performed an experiment with two rubber balls submerged in water. Each ball had a tube leading to a piston on the outside of the tank, by means of which air could be exhausted from or introduced into the ball. Whenever air was forced into both spheres at the same time, pulsations in the water caused the balls to move toward each other. When the pulsations were out of phase, the balls moved apart. The attraction was proportional to the amplitude of the contraction and expansion of the balls, proportional to the radii of the balls, and inversely proportional to the square of the distance between them. In short, they behaved exactly like particles of matter throughout the universe.

Korn based his theory on universal vibrations, caused by pulsating particles. The amplitude of the pulsation is considered very small in comparison to the size of the

(Continued on Page 24)

Snow-bound KDA-4 Firebee, flying the Canadian maple leaf, gets a final ground check at Cold Lake before trip north to Hudson Bay.

ARCTIC FIREBEES

U. S. Army and RCAF put Ryan Firebees through killing cold tests to evaluate Nike Hercules

An ice-melting blast pushes the Nike Hercules off its launching vehicle amid billowing clouds of snow dust. The missile weathered 55 degrees below zero temperatures before launch.

Ryan's "colonists" (l. to r.): kneeling, William Berry, Corp. William C. Careless, RCAF; standing, Gene Motter, Frank Wangsness, Bill Sved, Malcolm Miles, Don Loughran, Ryan senior reps.

THE KDA-4 version of the Ryan Firebee jet target missile, in service with the Royal Canadian Air Force, donned its PARAMI scoring and Luneberg pods last fall and prepared to report to Fort Churchill, Manitoba, Canada for winter duty.

Meanwhile, Ryanites Don Loughran, Frank Wangsness and Gene Motter packed long underwear in San Diego and headed north to the Fort Churchill site.

The Ryan target had been selected for "Operation Snowjet Hercules" a joint Canadian, U. S. Army operation designed to evaluate the Nike Hercules ground-to-air missile system under extreme cold weather conditions.

Under the joint operation directed by U. S. Army Lt. Colonel Joseph J. Larkin and Major Vernon Gay, Canadian Commander, the 600 mile-an-hour Firebee was the target of the Nike Hercules.

The delegation from Ryan joined many similar indus-

(Continued on Next Page)

Three-member Firebee flight support team huddles near the Fort Churchill hangar (l. to r.) RCAF F-86 chase, H-21 U.S. Army helicopter pickup, and RCAF Lancaster launch.

U.S. ARMY PHOTOGRAPHS

Pinnochio-like nose cone of Nike Hercules is checked by Lt. Colonel James T. Larkin, U.S. Army Project Officer for Operation Snow-jet and Major Vernon Gay, Canadian Commander.

At the Firebee ground control site (l. to r.): Flight Lieutenant Alec Short, RCAF; Don Loughran, Ryan; Flight Officer Roy Brown, RCAF; Pfc. Larry P. Beary, U.S. Army, plot drone's path.

trial and military groups from England, Canada and the United States to study the Continental Air Defense Command's worst natural enemy — bitter, destructive cold weather.

Results of the four months-long project, that began in November, remain classified, but members of the Ryan team now back in San Diego agree—weather in the Arctic is for the polar bears.

Fort Churchill is considered the coldest spot on the North American continent. Temperatures as low as 55 degrees below zero, driven even lower by cold arctic winds off Hudson Bay create gripping cold conditions that could

(Continued on Page 26)

← No place for toe-dip test as Firebee is dropped in Primrose Lake near Cold Lake, Canada, in pre-test operations.

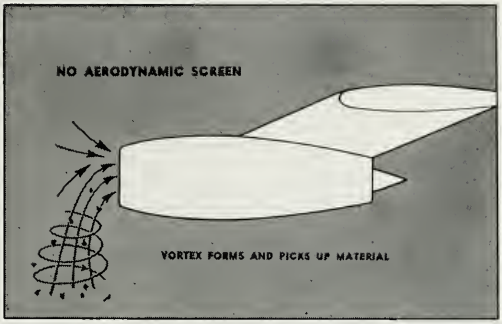
Down on the deck, RCAF Lancaster, with Firebee target drones tucked under its wings, streaks low over the Arctic wasteland.

Army H-21 awaits hookup by RCAF crew before lifting drone off the Arctic floor. Severe cold hampered work out-of-doors.

A JET engine will eat almost anything that gets within reach of its enormous suction. It digests very little, however. Mechanics who tear down the big engines are no longer surprised at what they find in the innards of the jets. Pliers, wrenches, cigarette lighters, hats, coins — almost anything that anyone can leave lying near the front end of a jet has found its way into the interior, usually with damaging effect. While a jet engine is not at all delicate, its precision machined turbine blades spin at high speeds in very close proximity to the stator blades. A pair of pliers in the wrong place at the wrong time can turn a beautiful piece of smoothly functioning machinery into so many pieces of junk.

While not so dangerous to the jet engine's well-being,

(Continued on Page 28)



A molehill of sand can become a mountain of trouble inside a jet. Runway debris can be sucked into the innards of the engine by the miniature tornado created by the jet's suction.

BLOW-AWAY JET

Douglas air broom keeps DC-8 pod free from runway debris

A THOUSAND TONS OF

Ryan streamlines production as 300th Boeing

Smooth-as-satin, bright-as-light aluminum skins reflect overhead lamps as KC-135 fuselage halves near completion in Ryan building.

TANKERS

KC-135 fuselage emerges

WHEN the 300th aft fuselage section built by Ryan for the Boeing KC-135 jet tanker-transport rolled off the assembly lines May 6, it was another milestone in a project that has been saturated with superlatives.

This has been the largest single unit ever subcontracted in the aviation industry for quantity production—40 feet long and weighing 3 tons—requiring the largest tooling fixture built at Ryan, a mammoth structure 60 feet long, 17 feet high and 15 feet wide. In this jig, looming majestically over all other tooling in the assembly building, are mated the aft fuselage's upper and lower halves to within tolerances of plus or minus .010 inch.

The aluminum panel "skins", requiring an unprecedented amount of spot welding of stringers, splicers and doublers, are the largest panels ever made at Ryan. An estimated 70,000 spotwelds are required in this aft fuselage section, presenting a complex handling and positioning problem as the "skins" move through the huge spotwelding machines.

Tooling and production difficulties were con-

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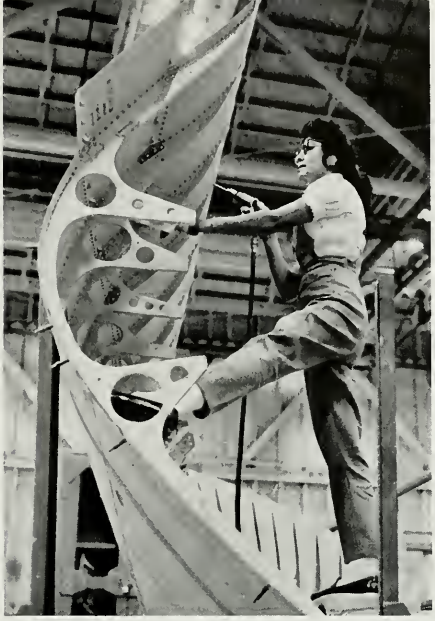
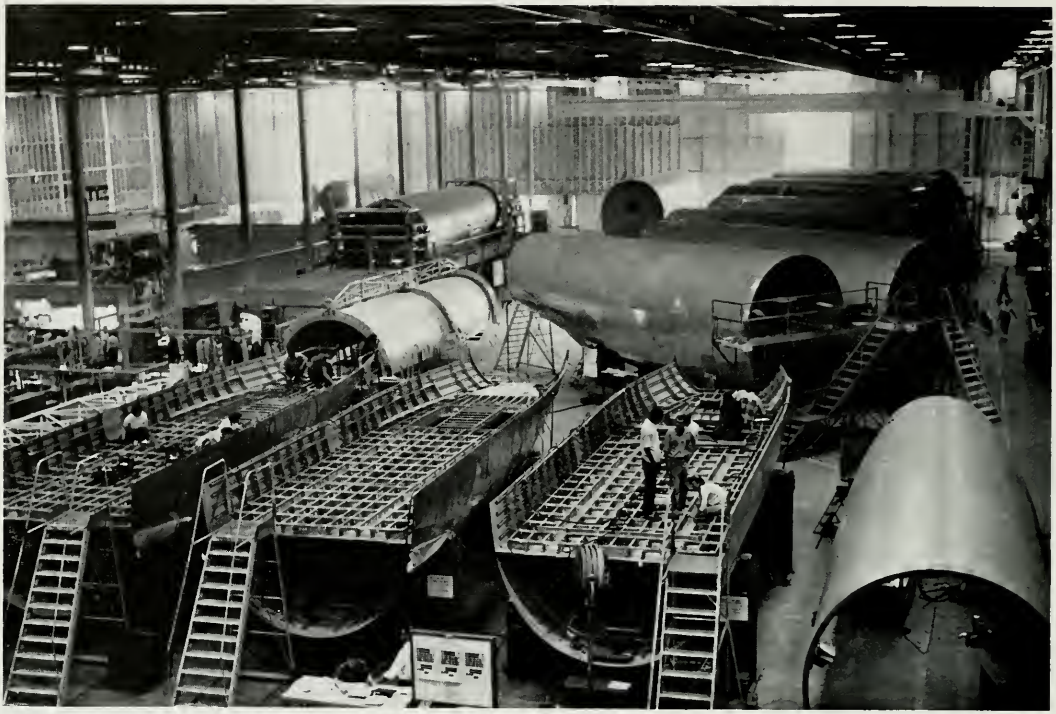


Flight is frozen into metal as the lobe of the KC-135 takes shape under the sure hands of Emma C. Castelum.

Interglobal range for the natian's air defense has its beginnings here. Under the arch formed by the upper lobe of the big ship, a Ryan worker fits in a key part.

Not a casing for the Holland tunnel, but the rib cage of the giant bird as it receives a final inspection from a mirror-wielding Ryan inspector, who insures that ribs and skin are joined in tight fit.



Freighters of the sky resemble ships of the sea in dock as Boeing giant transports are fitted with heavy load bearing decks.

From the bottom—down. Lela B. Davis and Bettie Beals work on lower half of KC-135 fuselage, which is built upside down to speed production.

quered with such rapidity that within 13 months, the first KC-135 aft fuselage section was completed and shipped to Boeing's Renton, Wash. plant. Bug-eyed railroad officials were so worried about whether clearances along the route were sufficient for the giant structure that there was some talk of shipping it by boat. But it just did squeeze through tunnels and bridges in the mountainous portions of the rail journey, and a steady flow of the fuselage sections for America's first jet tanker-transport—military version of the famed Boeing 707 airliner — has since been pouring through the supply funnel from the Great Southwest to the Great Northwest. The long line of KC-135 fuselage sections will continue emerging from the Ryan plant until at least late 1960, by which time the previous Ryan production record, set by work on another Boeing plane, the piston-engined KC-97 tanker-transport, will be within challenging distance.

For more than 7 years, without a break in delivery schedules, Ryan built nearly 900 of these units for the workhorse KC-97's, first of the Air

Force's big planes specifically designed to extend striking power by in-flight refuelling of bombers and fighters. In late 1960, Ryan will have had uninterrupted production of more than 400 KC-135 fuselage sections over a 5-year period.

During the life of the contract to date, Ryan has managed to maintain scheduled output despite major changes, instituted in the program, which required basic changes in production line flow patterns within the plant on two separate occasions. And while the changes, designed to improve performance and structural characteristics, were effected on completed sections in the production line, tooling proceeded to incorporate the new features simultaneously—a task which has been completed with no slowdown of production.

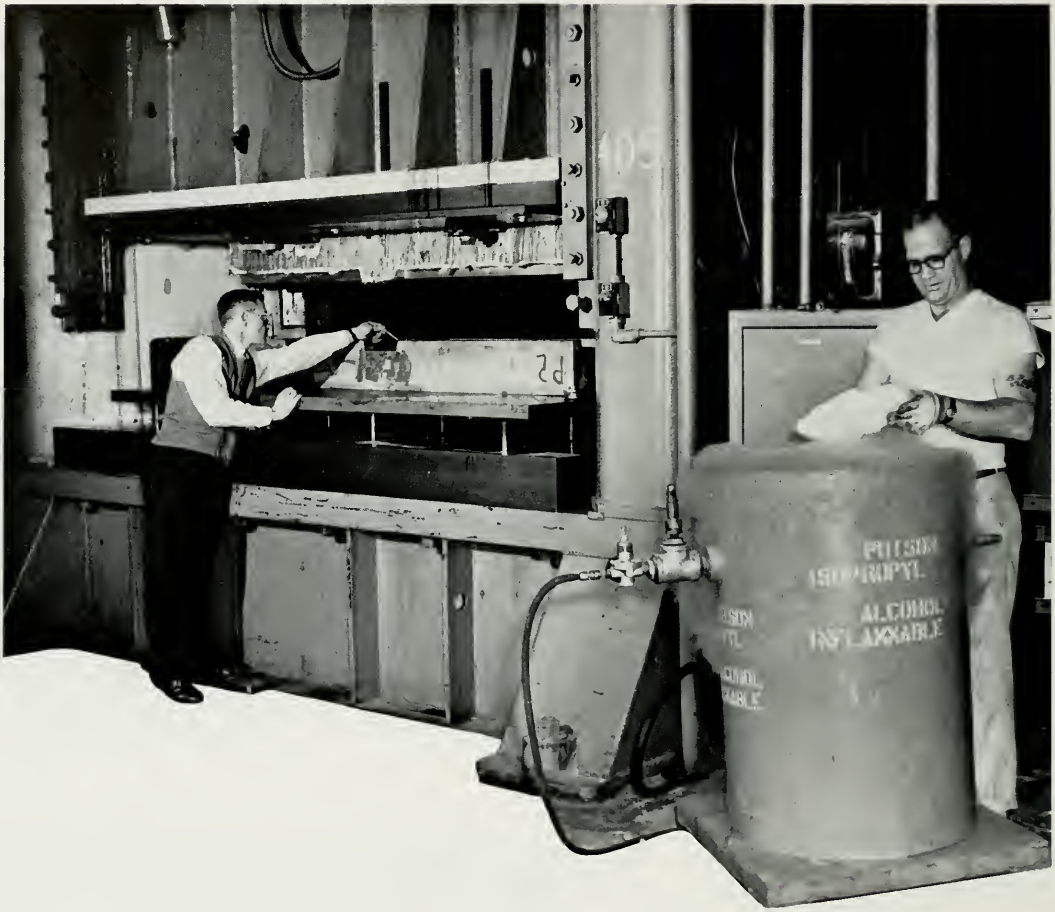
Assembly know-how accelerated so sharply that from Ship No. 60 to Ship No. 300, the amount of manhours required per fuselage section plunged more than 60 percent. This was accomplished by establishing a strict sequence of operations to avoid overlapping at work stations, and forming "teams" which move from one station to another, accomplishing exactly the same structural or "skin" assemblies at each station with increasing efficiency per unit.

Thus, in the lower lobe assembly, where six jigs are in operation, a fuselage section remains in its jig until all six crews have completed their specialized jobs in carefully sequenced rotation

(Continued on Page 24)

Dwarfed by the massive K-135 fuselage looming over them, Ryan workers ease the tanker component onto its flatcar for the long run from Ryan to Boeing. More than 300 of the giant units have thus far made the trip.

Long arm of the Free World's Sunday punch gets a lot longer when the Boeing B-52 fuel tanks are replenished by the KC-135.



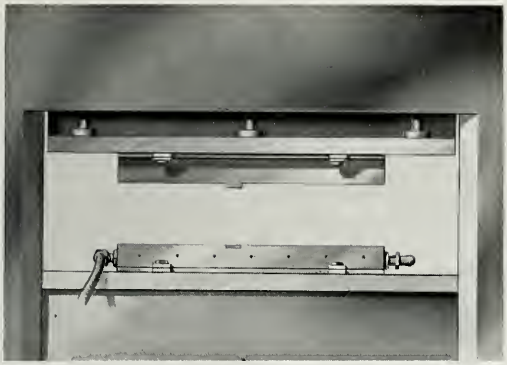
FAST FREEZE FOR HOT PARTS

WITH the invention of a new die-quenching process, Ryan has achieved a breakthrough in the rapid forming of tough heat-resistant alloys to precise shapes and degrees of hardness.

The revolutionary new process cuts the time required for a cooling cycle from 10 minutes to less than a minute. Just as important, it keeps the die in which the metal is chilled at a low temperature, permitting its constant use. Formerly, the cooling process would have to be stopped frequently, since the die would absorb heat from the red-hot metal until the die had lost its ability to quench the metal.

The invention has two separate facets. First, the die on which the metal is finish-formed is now cast with a three-inch iron pipe running longitudinally through its center. Holes are drilled through the face and sides of the die into the pipe, and the pipe is threaded on each end to permit the attachment of tubing. The tubing is connected to a portable cooling tank, which supplies cold dry air at sub-zero temperatures, at a pressure of 60 psi.

Before the die is put into operation, it and its companion punch are cold-soaked until both parts are at least 40°F or lower. During operation, the frigid air blasts through the die, keeping the die cold, and as the air escapes



Sketch shows typical die in place. Upper punch, made of lead, is protected from fierce heat of part by blast of frigid air which chills part to room temperature in less than one minute.

Cold air comes into the die from a tank filled with dry ice and alcohol, is played onto part through the holes indicated by Ryan Engineer John F. Reeser, inventor of the new process.

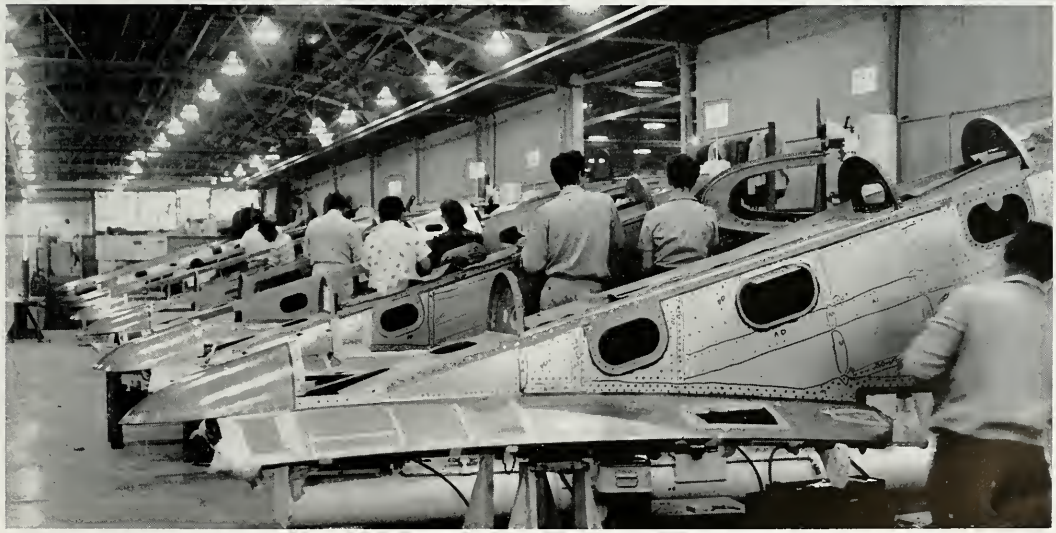
through the holes drilled into the face of the die, it chills the part to the desired temperature nearly ten times as fast as the previous method.

The second of the two inventions is the portable cooling tank. This is a barrel approximately three feet high and 26 inches in diameter, and is mounted on casters. Inside the barrel is an airtight tank approximately 14 inches in diameter and 22 inches high. A three-inch diameter pipe runs through the side of the barrel, into the tank and within two inches of the bottom of the tank. This air intake pipe is equipped with a connecting tee for air intake from the plant pressurized air supply, a pressure regulator, and a safety valve. Extending from the top of the tank through the barrel on the side opposite the intake pipe is the air discharge pipe, which is connected to the pipe embedded in the core of the quenching die.

The inner tank is filled with dry ice, and the space between the tank and the barrel is filled with isopropyl alcohol and dry ice. Air is forced through the dry ice to the

(Continued on Page 28)

Quick freeze puts hot parts into Ryon production lines, like this DC-8 pylon line, in fraction of the time previously required.



RYAN'S continuous-wave Doppler navigational systems (RYANAV*) are extending the operational capabilities of nearly every type and size of aircraft, from terrain-hugging helicopters and reconnaissance planes to high altitude, high speed jets. Based on twelve years of research and development in C-W Doppler, and thousands of hours of flight experience, the RYANAV systems employ the most advanced aerial navigation concepts in use.

NAVY NAVIGATION:

Typical of Ryan C-W Doppler systems is the APN-122(V) radar navigation set which is being produced in quantity for the Navy. Adaptable for almost every type of Naval aircraft, these systems are being installed as standard equipment in land-based patrol bombers, ASW seaplanes, ASW hunter-killer planes and attack and special purpose aircraft. The APN-122(V) is a two-beam system that automatically and continuously computes and displays ground speed and drift angle. It provides outputs for tie-in with ground position computing and indicating equipment, course and distance computing and indicating equipment, inertial navigation equipment, bomb director sets, ASW sets, and terrain clearance radar. This versatile system can be used in conjunction with integrated flight systems, automatic pilot and flight direction systems for very low as well as very high altitude aircraft.

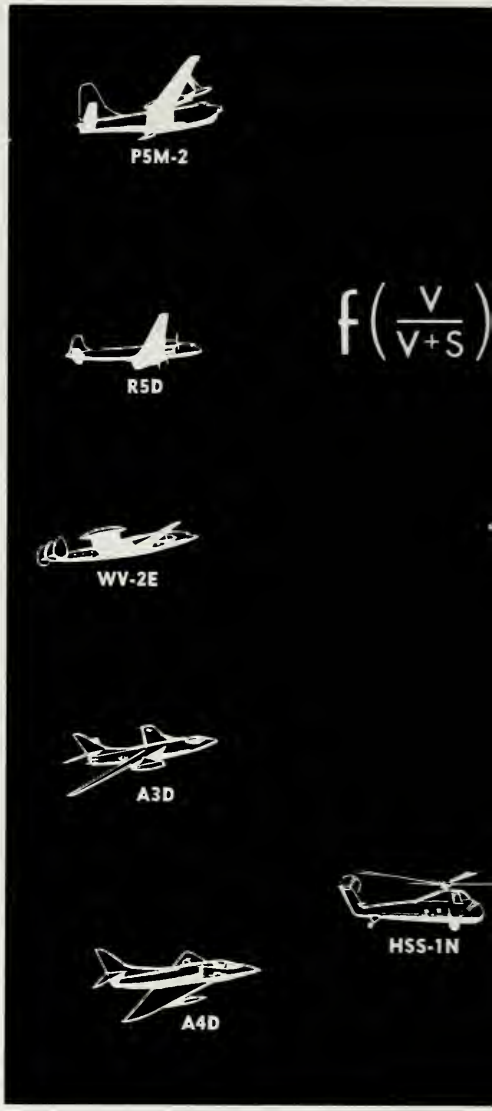
Also in production is the Ryan AN/APN-97 C-W Doppler radar set, a four-beam system designed to make sustained precision hovering possible under zero/zero visibility. This system is now in operational use in Marine helicopters and with Navy ASW squadrons. It automatically and continuously displays the heading speed, the drift speed, and the vertical speed of the helicopter. The equipment can be tied in with automatic stabilization systems to permit smooth safe automatic transition from cruise speed to hovering condition.

The Ryan APN-125 system, similar to the APN-97 in many respects, was developed to provide Navy ZPG-2 and ZPG-2W airships with all-weather automatic navigation and hovering facilities to extend their AEW and ASW capabilities.

ARMY NAVIGATION:

The Ryan AN/APN-129 is an integrated automatic navigation and flight control system developed primarily for low-speed "nap-of-the-earth" operations performed by reconnaissance aircraft of the Army L-20, L-23D Seminole and AO-1 Mohawk types. The system automatically computes and displays ground speed, drift angle, ground position, ground track, wind speed and direction, course and distance to destination and the aircraft's heading and flight attitude. It also contains a magnetically-slaved heading reference system and a dead-reckoning position indicator.

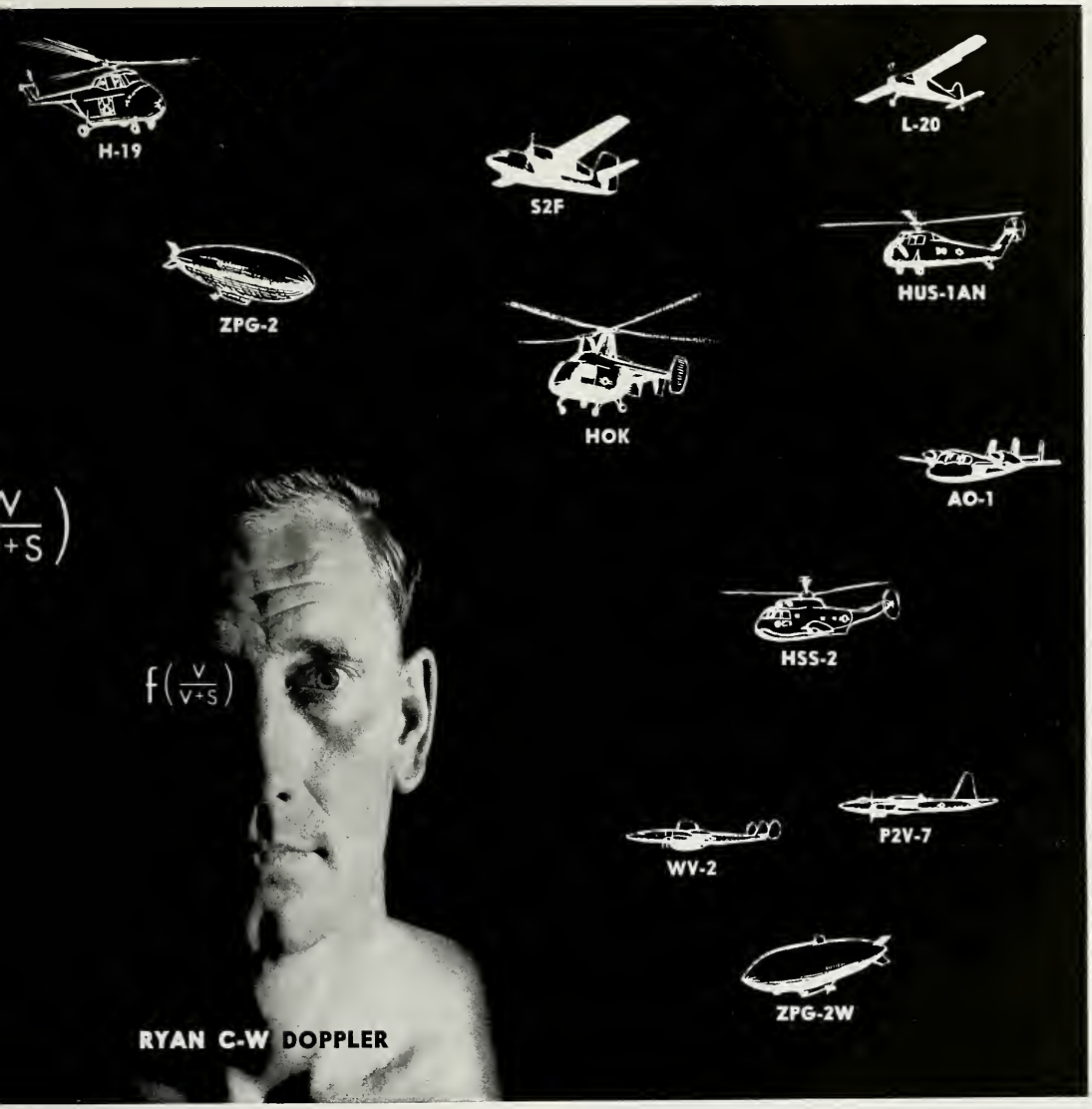
The Ryan Model 120B combines an integrated automatic navigation and flight control system (AN/APN-129) with hovering equipment to provide a helicopter with all-weather navigation and hovering capabilities. This system is used in Army H-19 and H-34 helicopters.



RYANAV: FOR

Major aircraft

* Trademark



ULA FOR JET AGE NAVIGATION

y on Ryan Electronics Systems for navigation

RYAN RECEIVES $17 MIL

FOR KC-135 JET TANKER-TRANSPORTS: $8 MILLION

An $8 million order for additional Boeing KC-135 jet tanker-transport aft fuselage sections was announced recently at the annual stockholders meeting. A follow-on order to the original KC-135 contract orders received by Ryan in November 1954, the revised contract continues current production of the fuselage sections through August 1960. Commenting on the new follow-on order, T. Claude Ryan, president and chairman of the board, said the KC-135 program is one of the mainstays of the company's subcontract program. The new $8 million order boosts the total volume of KC-135 business to approximately $70 million. Ryan, now well into its sixth year of production of the KC-135 fuselage, has shipped more than 300 units to Boeing. Ryan started production of the aft fuselage section after building hundreds of aft fuselages for the KC-97 tanker-transport — the piston-engined predecessor to the KC-135.

FOR HELICOPTER ELECTRONIC DEVICES: $2 MILLION

Over $2 million worth of AN/APN-97 helicopter hovering devices, plus spares, are ordered in a contract from Sikorsky Aircraft Division of United Aircraft Corporation. The Electronics Division will produce a portion of the contracted units for Sikorsky craft and the remainder for installation in helicopters by Westland Aircraft Ltd., of England. The AN/APN-97 enables a pilot to hover his helicopter automatically without ground or visual reference. By placing the helicopter control at the desired setting, and with no further manual assistance, the pilot can bring the aircraft to zero ground speed over a pre-selected spot. Navy units have received the new device which increases the capabilities of ASW operations, and Marine squadrons are being supplied with the hovering equipment, the result of years of pioneering research in continuous-wave Doppler systems.

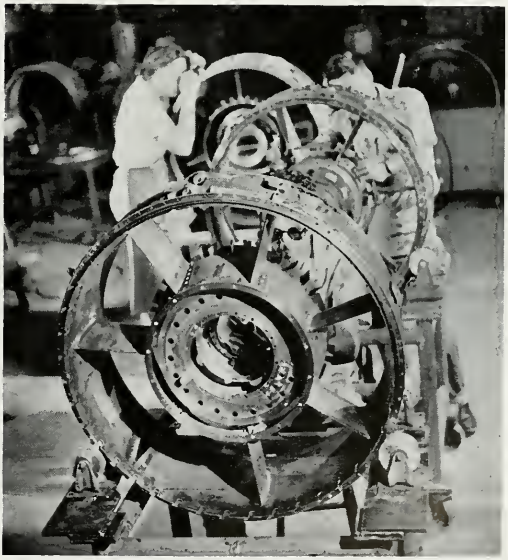
ON IN NEW CONTRACTS

FOR RYAN FIREBEE JET TARGETS: $4 MILLION

Included in $17 million worth of orders announced recently by Ryan is a $4 million contract for modification of Firebee jet target missiles and support equipment for Project William Tell II. The contract calls for the rehabilitation of 54 William Tell targets and the design, fabrication and installation of scoring equipment on all targets designated for the meet. A total of 110 Firebees have been ordered for the William Tell shoot to date, including the 54 rehabilitated targets and 56 drawn from Air Force inventory. The Air Force contract also calls for additional ground support equipment for the meet, including trailers, adapters, slings, mobile hoists, wing and tail leveling units, pre-flight test units and hard stands. Technical personnel will also be supplied to the meet under terms of the contract. William Tell II will be held in October, 1959, and will pit the nation's top interceptor teams against the Firebee.

FOR JET, ROCKET, PISTON ENGINE PARTS: $3 MILLION

Contracts for $3 million worth of rocket motors, exhaust manifolds and other "hot parts" for jet and piston-type engines have been received from the Air Force, the Firestone Tire and Rubber Company, and the General Electric Company. The contracts extend Ryan's high temperature components' production through mid-1960. The Air Force contract orders additional piston engine exhaust systems and spare parts for the Douglas C-124 Globemaster. Firestone, Los Angeles, has ordered a substantial additional quantity of liquid fuel rocket motors for Army "Corporal" missiles, while the General Electric contract calls for extended production of jet engine cones for the powerful J-79 turbojet engine. Ryan has fabricated the high temperature exhaust systems for the C-124 since June 1948. The Firestone order extends production of Corporal rocket motors initiated in 1951.



P. D. Q. JET PODS

Ryan DC-8 quick engine change kits cut airline downtime to minimum

Boards, key to accurate build-up, are filled from racks by Asst. Supr. C. E. Zumwalt, B. L. Orozco, E. M. Jacobsen, C. G. Fordem.

$1,000 an hour—and more—is the amount of revenue that a modern jet airliner can ring up on the cash register for its operators. It can't ring up a single cent when it's sitting still, grounded because an engine won't work.

Lost time is the economic bugaboo of modern airline operations, and much of the time lost comes from engine repair and maintenance. As simple as the new jet engines are to maintain—in comparison to their piston-powered brothers—they too run into unforseen accidents, and must, of course, undergo the periodic overhaul specified for all engines by the Federal Aviation Agency or its counterparts in other nations.

Since engine repair and overhaul, then, seems to be the main factor in lost time, it's important to get a sick or tired engine off the aircraft, and a new and healthy one on, just as quickly as possible. Douglas and Ryan engineers, working closely together, took some important steps to insure that engines could be serviced or changed on the DC-8 in the barest minimum of time.

First, they put quick-opening access doors around the engines; second, they set up quick-disconnects on the engines so that they could be removed from attaching points easily; and third, they provided engine build-up kits which will enable using airlines to build up engines to a point where a complete engine change can be made in a matter of minutes. In fact, an engine substitution can be made on a DC-8 in little more than a half-hour, compared with the three to six hours required for a piston engine.

These engine quick change kits—which contain all the parts necessary to turn a bare-bones Pratt & Whitney JT-3 or -4 into a full-rigged power plant—are produced and assembled at Ryan, shipped to Douglas for addition of thrust brake and noise suppression mechanisms, and transhipped to their final destination at the main maintenance base of the using airline. Each kit contains more than 500 detail parts and all accessories—fuel pump, gener-

(Continued on Page 25)

On with the new. Airline mechanics can swing an old engine off, swing a new one on in about a half-hour. Engines are built-up with Ryan quick engine change kits.

Ryan's Glenn R. Legg fits a part to a DC-8 power plant. Rack at right holds all parts in correct installation order, helps prevent operation of Murphy's law.

AIR FORCE REPORT:

RYAN FIREBEE AT PROJECT WILLIAM TELL

Reprinted from THE AIRCRAFT FLASH—January, 1959—a publication of the Air Defense Command, U. S. Air Force.

AMONG the outstanding equipment performances at the Tyndall meet was that of the Ryan (Q2-A) Firebee, a free-flying drone of extraordinary refinement and flying capabilities, which was used as the target to test the mettle of the intercept teams.

Nearly 100 of these remarkable little jet-propelled flying machines were used during the meet, and of that number more than 20 were actually knocked out of the sky by direct impact of weapons. Some statistics give an idea of what the interceptors were up against in facing the Firebee:

Speed, 600 miles per hour. Altitude capability, up to 53,500 feet, although it was not flown above 42,000 feet during the Tyndall competition. Flight duration, one hour and 40 minutes, with a control distance of 152 miles from control and return.

The Firebee has a wing span of approximately 12 feet, stands roughly six feet high and has an overall length of less than 18 feet.

This slick little aircraft, however, is not for shooting down, but rather is designed to measure the miss distance of firings by interceptors. In this capacity, the Firebee becomes an even more remarkable aircraft for, in addition to obeying flying instructions from the ground, it can record the distances between itself and the weapons fired at it, to determine accuracy of firing.

The measuring system utilized in this procedure is called PARAMI (short for Parsons Ring Around Miss Indicator) and consists of electronic transponders in the missile being fired and in the wing pod of the Firebee which set up pulse frequencies when they come in contact. The measure of these pulses, taken by ground equipment and taped out for use by the scorers, tightens as the missile and the drone come into closer proximity, thus indicating the miss distance.

In the case of 2.75 rockets, which are too small for installation of PARAMI, the drone carries a special "Traid" camera to provide an actual picture of the miss distance of the rocket. As a result of these two systems, the measuring of the miss distance for scoring at Tyndall was quite accurate.

The drones are so light in weight — 1,800 pounds with fuel — that two can be loaded under the wings of a World War II B-26 for air launching. As soon as they are fired up and launched into free flight, they are "acquired" by ground control and maneuvered as necessary for intercept test purposes.

These little aircraft can be flown again and again, and one of the interesting operations of the meet was the recovery of the drones after they had dropped into the Gulf. Because their falls are broken by large parachutes, the drones sustain little or no injury on hitting either the water or the ground. At Tyndall, Air Force helicopters were on constant standby to spot and pick up the drones as soon as their parachutes folded.

The recovered drones were returned to Tyndall immediately from the retrieving station (located at Apalachicola, Fla., some 75 miles east of Tyndall) for repair and refitting for further use. This operation saved hundreds of thousands of dollars. Even drones smashed beyond repair by direct hits were "cannibalized" for their undamaged parts, which were reused.

Anticipating the need for higher speeds to properly test the Air Defense Command's growing inventory of supersonic manned aircraft, as well as the unmanned BOMARC, Ryan is already working on a new and improved remote-controlled Firebee of greater speed, altitude and general performance capabilities. This new drone may very well see action at next year's weapons meet. It would be fair to say that the Ryan Firebee made the biggest single contribution to the meet's realism.

"And all I ask is a tall ship,
and a star to steer her by."
John Masefield

EVER since man first decided to satisfy his curiosity concerning the other side of the hill, he's been plagued by the problem of navigation—how to get to the other side of the hill and back home in the most direct manner.

From the first clumsy astrolabe to the precision automatic electronic navigation systems designed and produced by Ryan, man has constantly tried to more and more accurately pinpoint his position on the surface of the earth—or above it.

Ryan C-W Doppler systems meet the demands of high speed jet flight

As time went on, he invented various instruments and techniques—the sextant, the chronometer, the compass, sidereal time, the radio direction finder, —all of which still serve well—on surface ships. They became obsolete for one type of travel on December 17, 1903.

Determining one's position with traditional navigational instruments takes time. With the best of instruments, and a healthy dose of luck, the final result is also apt to be only fairly accurate. A sight with a marine sextant, for example, will be accurate to within tenths of a minute of arc—and somewhat less than that when the sight's taken from the pitching deck of a steamer in a gale. An aviation octant may give a sight as far off as 120 miles. When you're tearing along at 750 miles an hour or better, you just don't have time to correct mistakes like that. Before you can say Connecticut, you're in Maine.

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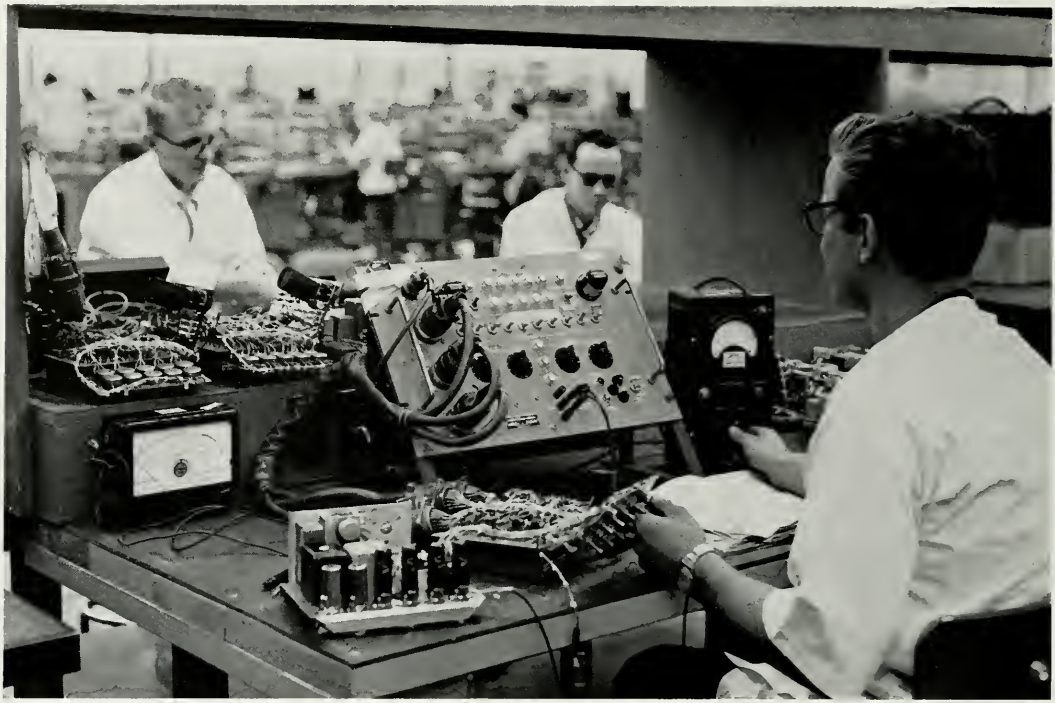
From Dead Reckoning to NAVIGATION BY RYANAV*

* Trademark



Test engineers in Ryan's Electronics Division plant get pinpoint performance from RYANAV systems by checking every component.

RYANAV automatic electronic navigation system is adjusted by navigator on Navy WV2 Constellation plane. Compact black box replaces time-consuming navigation done with bubble octant, compass, airspeed indicator, drift-meter and charts.

It was a bit different when man first started to roam. He was at first able to blaze a trail by scarring trees or setting rocks in piles. Eventually came the day when the hills he wanted to see the other side of were across areas without trees or rocks, and man looked to the sky for a star to steer by. Stars sufficed until man found he was wont to stray rather badly when he took star sights from the tossing decks of tiny ships. So he stayed within sight of land.

Not until the 14th century did Western man find the key that opened the gates to the oceans. He found the magnetic compass. Although the Chinese had been using the compass since about 1000 B.C., it was not introduced into the Mediterranean area until Marco Polo returned with it from his travels through Cathay. With the compass, Western man discovered the New

World, circumnavigated the globe, established empires in the Americas and in the Far East.

Even with the compass, however, navigation in the Age of Discovery was apt to be a hit or miss affair. The compass needle hunted for North according to one's position on earth, and the clumsy astrolabe and cross-stick made navigation a rather haphazard science at best.

And, while the determination of latitude and the direction of one's course could be ascertained with pretty good results, longitudinal position was still found by guess or by grief, and most often the latter. Not until 1735 was the chronometer invented, and its discovery was considered so important that its inventor was awarded an enormous sum of money for his work.

Today, the compass has evolved into the highly sophisticated gyro-compass, with its companion auto-pilot, and detailed charts showing the amount of compass deviation are available. The clumsy astrolabe and cross-stick have become the precision instrument known as the marine sextant. Back of these instruments stand such devices as the radio direction finder and Loran.

Aviation has adopted the seafarer's instruments. The gyro-compass has been lightened, made smaller, and has been coupled to an auto-pilot designed for aircraft service. The sextant has been transformed into the octant, in which a bubble takes the place of a natural horizon. A drift-meter, to determine the sideways motion of the airplane due to wind force, has been added. And, of course, the radio direction finder—and other radio aids—have come aboard the airplane. It also has taken on an airspeed indicator and altimeter.

When aviation borrowed the mariner's navigational equipment, however, it failed to get the accuracy built into the heavier instruments used on shipboard. Further, some of the instruments peculiar to aircraft navigation have inherent errors. The altimeter, for instance, has indicated reading errors and variable errors, which must be accounted for in final computations. The

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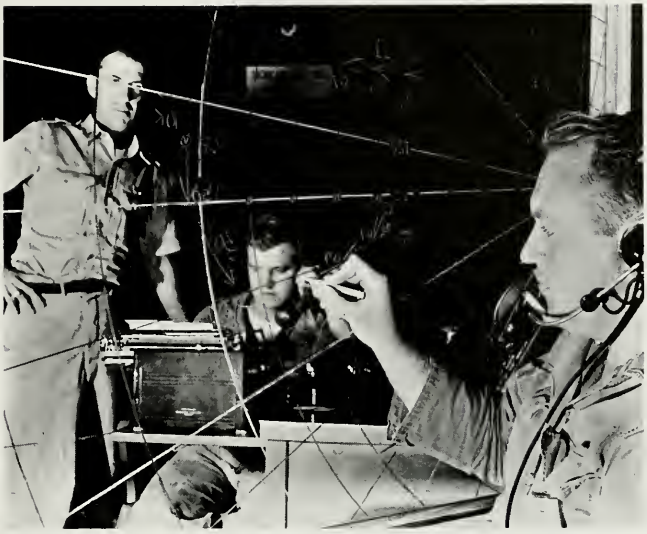
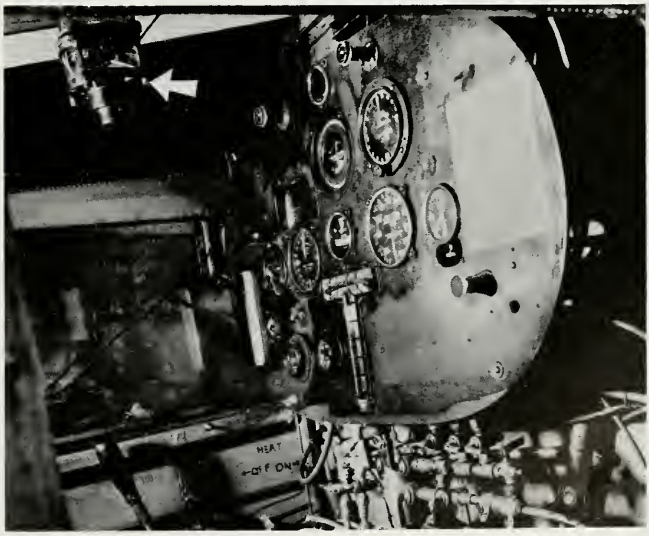


RYANAV systems are completely self-contained, do not require ground facilities and can indicate accurate position instantly to traffic control stations, such as this range surveillance team, shown plotting plane positions at Cape Canaveral.

Navigation, in the early days of flight, was largely done "by-guess-or-by-grief" dead reckoning, using crude instruments like the compass shown in this photo of aviation's most famous airplane, Lindbergh's Ryan-built Spirit of St. Louis.



NEW SIKORSKY HELICOPTER HERE FOR RYAN INSTALLATION

One of the Army's newest aircraft, the Sikorsky H-34 cargo-type helicopter, recently arrived at Ryan for installation of the RYANAV Model 120B integrated automatic navigation system and hovering device.

Several months ago, the U. S. Army Signal Supply Agency, Ft. Monmouth, N. J., awarded Ryan a $1 million order for these electronic systems, on which testing has been started at the Army Electronics Proving Ground, Ft. Huachuca, Ariz.

The big H-34, with an 18-passenger capacity and an external sling capability of 4,000 pounds, was flown here from Ft. Huachuca by Lt. Carl O. Johnson, and will remain at the Ryan plant for several weeks during installation of the Model 120B.

A predecessor of this system, the Model 120A, was installed some time ago in two De Havilland L-20 Beaver small liaison planes, and consisted of an automatic navigation system.

Subsequently, the Model 120B was produced to combine the functions of the automatic navigator with the self-contained helicopter hovering device that can guide a "chopper" automatically from normal cruise condition through transitions in both speed and altitude to a hover over a given location.

Robert Foust, Ryan flight line mechanic, points to where antenna of Ryan automatic navigator and helicopter hovering device will be installed. At left is pilot of new Sikorsky H-34, Lt. Carl O. Johnson, and in center is crew chief, Specialist 6C Forrest D. Robbins.

FLIGHT BY GRAVITY

(Continued from Page 3)

pulsating sphere, and the duration of the pulsation is considered to be extremely short.

"A significant step," Korn says, "was taken by assigning to gravitation a dynamic cause and by replacing the concept of action through voidness by an action through an intervening medium."

The intervening medium, or universal continuum, is considered to be almost perfectly incompressible. Therefore, the pulsation of the sphere, or particle, causes an excitation—a velocity potential—in the continuum, which, because of the medium's incompressibility, is propagated through the universe, much as ripples are formed when a stone is dropped into a pond.

All pulsations by all masses in the universe are in harmony with a basic pulsation. This basic pulsation is considered to be the cause of gravitation. Attractive forces between groups of particles are generated by their universally basic pulsations.

There is a very practical reason for a determined inquiry into the cause of gravity.

Those who now view the planets and the stars as man's newest frontier have come to realize that chemically fueled space ships just won't do. Mercury, in comparison to the almost inconceivably vast distances of the universe, is just next door; and Proxima Centauri, our nearest stellar neighbor, is 25,000,000,000,000 miles away—four light years. To move from our sun to the center of our own galaxy would take 26,080 years, moving at the speed of light. It is clear that some means of propulsion which will give man speeds approaching that of light must be found. And, if Dr. Edward Teller is correct when he states that time "shrinks" when measured within an object that is moving at nearly the speed of light, an earth spaceman could travel to points a million light years distant and return, all within his lifetime.

If gravity is an energy flux, like electricity and light, why not harness it as a motivating power? Majorana's experiments indicate that masses can be shielded from the effects of gravity. Would it be possible to erect screens against the force of gravity, to turn its effects to advantage?

If so, the space navigator of the future could turn his craft in the direction of the planet or star to which he wished to travel, erect shields against all other gravity forces, and travel to his desired destination.

Written by James J. Mulvey from a paper presented by Vjekoslav Gradecak, Ryan Senior Structures Engineer, to the American Astronautical Society.

TONS OF TANKERS

(Continued from Page 11)

before the lobe is carried by crane to the next station.

As No. 300 moved into San Diego's sunlight and was hoisted on to a flat car for the trip to Renton, the assembly line clatter presaged more milestones to add to the distinguished history of the KC-135.

P. D. Q. JET PODS

(Continued from Page 19)

ator, oil sumps, etc. The complete nose cowl is a separate component.

Shipment of the kits is made in two crates. One contains the nose cowl and its components; the other contains the detail parts and the engine accessories. Small parts—clips, braces, angles, fuel, oil, and air lines—are sealed in polyethylene bags and stapled to 4-foot square painted plywood boards. Each piece is fastened to the board in the exact sequence in which it's to be placed on the engine.

Not only is the build-up job speeded up by this sequencing of parts, but an important safety factor is added. If the assembling mechanic finds parts left on the board at the end of a particular operation, he goofed. Further, if fuel and oil lines, for instance, are not supported by the right brackets in the right places, vibration can cause rupture, with fire or loss of control resulting. The Ryan packaging system helps prevent improper assembly, and foils the operation of Murphy's law.

After engine-build-up at a main base, the airlines will spot complete engines at various bases along their routes, so that—in emergencies—engine changes can be made without waiting for new engines to be flown from main bases. Engine changes made because of periodic overhaul will be made at main maintenance bases.

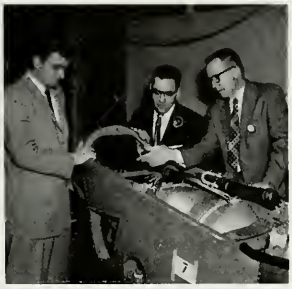
These replacement engines will be complete with all accessories, including electrical harnesses, plumbing, nose cowls, and access doors. Mechanics, when switching engines, will merely have to disconnect the various electric, hydraulic, air, fuel, and oil systems and controls, drop the tired engine into a waiting cart, set the new engine in place, hook up the systems and controls, and ground test the new unit. The whole procedure will take less than an hour.

Rather than replacing an individual part or system — the generator, say, which, with its constant speed drive unit, might take several hours, the airlines save the thousands of dollars in time lost by simply hooking up a new engine and correcting the generator trouble at their leisure.

115 kits are presently on order. A total of more than 170 will eventually be delivered to Scandinavian Air Lines System, KLM, Swissair, United Air Lines, Pan-American Airways, and to the rest of the airlines around the world who have ordered the Douglas DC-8 Jetliner.

Even though nearly every airline differs from its fellows in just how it wants its engines, and thus complicates the build-up procedure, Douglas, Ryan and Pratt & Whitney have successfully met the challenge by collaborating in publishing the required training phases, and will provide technical assistance in the field, anywhere that the magnificent new Douglas airplane is operated.

Visitors Examine Ryan Facilities



Recent visitors included Peter David MacMahon, assistant chief of development in charge of electronic systems for all-weather helicopters, Westland Aircraft, Ltd. England, and Joe Jordan, Staff Engineer, Wright Patterson Air Force Base. Accompanied by Cliff B. Smith, Manager of Customer Relations, Electronics Division, MacMahon is shown in photo at left viewing production line at Kearny Mesa plant. Jordan, in center of photo at right, inspects a Firebee XQ-2C engine nacelle with Bill F. Owens, Drone Projects Office, at left, and Forrest Warren, project engineer, Drone Development.

Royal Canadian Navy officers who recently visited plant are shown examining DC-8 pylon under guidance of J. N. MacInnes, at right, of Ryan military relations. Left to right, Lt. F. J. Dayton, Lt. Comdr. A. W. Boden, Rev. Hugh McGettigan; Lt. Comdr. A. A. Hodge, and Lt. G. B. Stanford. While here, the officers also were briefed on the performance and function of the Firebee jet target drone missile.

ENDURANCE RECORD SET FOR KDA-1 TYPE NAVY FIREBEES

An endurance record for the Navy KDA-1 series of Ryan Firebee jet target drones was set recently at the Navy Ordnance Test Station, China Lake, Calif.

While flying in support of a Sidewinder missile mission, a KDA-1 target remained in the air 55 minutes during which it was on target station four times.

On completion of the mission, the Firebee was flown to the recovery area and recovered by its parachute system.

The all-time endurance and altitude records to date for any Navy production jet target were set late last year by a Ryan KDA-4, an advanced version of the KDA-1, at Pt. Mugu, Calif. Naval Missile Test Center. This latest production model Firebee attained an altitude in excess of 48,000 feet, and remained in the air for 78 minutes, all but seven in powered flight. It glided to 14,000 feet on fuel depletion, and parachute recovery into the ocean was commanded.

More recently, the newest Navy Firebee, the XKDA-2, reached an altitude of 49,000 feet on one of its early test flights at Pt. Mugu.

Ready for another mission at the China Lake, Calif. Navy Ordnance Test Station, this Ryan Firebee recently set an endurance mark for the KDA-1 series of Navy jet target drones—55 minutes in the air in support of a Sidewinder missile mission. At left is the remote controller on the record-breaking mission, Lieut. Comdr. McIlmoil, and at right is Chief Dodd, who served as launch operator on the "mother plane."

ARCTIC FIREBEES

(Continued from Page 6)

kill a man in minutes.

"Despite heavy arctic clothing, supplied by the U. S. Army, our breath formed chunks of ice on our face masks," the Ryanites stated. Working outdoors without fur-lined gloves was an impossibility.

Although the warmth-loving San Diegans were a bit dubious, the weather was ideal for smoking out the cold bugs in the Nike-Hercules system.

The Firebees —U. S. Navy KDA-4 versions—were prepared for the cold weather tests by the Air Armament Evaluation Detachment of the Central Experimental and Proving Establishment at Cold Lake, Alberta, Canada, a major weapons firing range, about 700 miles southwest of Fort Churchill.

Delivery of the drones to the RCAF squadron began last summer and the first training missions were flown in October. Training flights of the drone in the heavily wooded, lake-studded Cold Lake area resembled a game of "drop the clothespin in the milk bottle."

Primrose Lake, a three-mile-wide hole in the dense woods, was selected for the desired recovery impact site. Forty mile-an-hour winds at 15,000 feet frequently complicated the operation.

To solve the problem the Canadians launched a weather balloon with a radar reflector attached. The balloons, tracked by radar, revealed the necessary drift data. To compensate for the excessive drift, parachute commands were sometimes initiated as much as five miles upwind of the pre-selected water impact area.

Training and testing were accomplished under the watchful eye of Bill Sved, Ryan's permanent Service Representative at Cold Lake. This phase completed, the drones were tucked under the wings of an RCAF Lancaster and flown to Churchill for operational duty against Nike.

The KDAs, nestled under the wings of the Lancaster awaiting flight assignment, were housed in the only large hangar available at Fort Churchill. Arrival of an MATS transport plane with a load of perishable vegetables for delivery to Arctic Circle outposts occasionally forced the "mother" plane and her brood out of the warm roost for the night.

Forced out of the "refrigerator" into the "deepfreeze", the drone's battery was removed and electric autopilot circuits were shrouded with heating blankets.

"The best preparations seemed hopeless at times," Don Loughran later observed, "the extreme cold penetrated everything." Despite the conditions, the spunky Firebee, after a few minor adjustments, was ready to fly.

"The day we launched our first drone, the ground temperature was 47 degrees below zero," Don recalls, "the outside air temperature at the 12,000 foot launch altitude was minus 50 degrees. As in any operation of this type we encountered many problems. However, on the long end of a dozen flights, the drone's performance average was highly satisfactory."

The Nike Hercules, the second in the Nike Missile series, is a land based, combat ready, mobile surface-to-air guided missile in service with the U. S.

(Continued on Next Page)

ARCTIC FIREBEES

(Continued from Page 26)

and Canadian Armies. A major advance in the Nike family of guided missiles, the Hercules is rated considerably more effective than its predecessor, the Nike Ajax. A relatively inexpensive and simple solid propellant missile, the Hercules is capable of carrying a high explosive or nuclear warhead.

Fort Churchill, Manitoba, Canada is on the western shore of Hudson Bay, 540 miles south of the Arctic Circle and 620 miles north of Winnipeg. Natural residents are Eskimos, Indians, polar bears, and white fox. A two day Canadian Northern Railway train ride over frozen wasteland is the only link in ground transportation with the historic fort. The 600 mile long, one track spurline, marked by numerous rest stations along its route, originates in Winnipeg.

The Fort Churchill colony is divided into two parts, the military post of the Royal Canadian Army, and Churchill Townsite, a community of Eskimos, Indians and French-Canadian settlers. Churchill Townsite boasts a gas station with one gas pump—petrol 60c a gallon—two hotels with beer bars and a curio shop.

On the site where the original Hudson Bay Company was founded in 1670, a new modern Hudson Bay Company department store now stands. Unusual items on sale include sealskin bow ties and sealskin moccasins. A trading section in the rear of the building carries on fur trading with the Eskimos.

"Fort Churchill is similar to any military post," the Ryanites agree. "Except —it goes underground in the winter." Wooden tunnels actually built at ground level connect the various dining halls and barracks. Covered by driving blizzards in the winter, the tunnels close out the weather and allow safe passage between the buildings.

"A varied recreation program," Don Loughran agrees, "made life bearable in the arctic wilderness." Darts were the favorite pastime when early sunset cut down valuable daylight working hours.

"Operation Snowjet Hercules" featured the use of seven KDA-4 type Firebees. Twelve flights were made to altitudes as high as 36,500 feet with flight durations up to 31 minutes.

Although exact results and analysis of the tests are classified, the U. S. Army, and the Royal Canadian Air Force considered the project successful both from the standpoint of Firebee performance and results of missile evaluation.

DISTINGUISHED VISITORS HERE

Canadian military officers who recently visited Ryan's San Diego plant are shown in the DC-8 jet engine pod and pylon assembly area, with Ray "Butch" Ortiz, Assistant Factory Manager, second from left, and J. N. MacInnes, of Ryan Military Relations, fourth from left. The officers, who also received an intensive briefing on Ryan's most advanced Firebee jet target drone, the XQ-2C, are left to right, Navy Lt. Comdr. Nels Banfield, and Lt. G. L. Giroux; Army First Lt. George T. Mainer; Navy Lt. R. E. Beaoregard; Army Capt. J. L. Sharpe; and Navy Chaplain C. H. MacLean.

Officers from Firebee base, Brown Field Naval Auxiliary Air Station, recently spent a full day in the Ryan San Diego plant, where they were familiarized with the jet target drone production and engineering program, Ryan's work in VTOL (vertical take-off and landing), and electronics developments. Shown with John MacInnes, of Ryan Military Relations, and Ernie Mellinger, senior tool research engineer, fifth and sixth from left, on plant tour, they are, left to right, Lt. Comdr. B. T. Smith; Comdr. Gale Burkey; Comdr. E. G. Wendorf, Capt. R. S. Riddell, Lt. C. J. Brammeier, and Comdr. C. S. Brooks.

TAC COMMANDER ASKS FOR VTOL/STOL AIRCRAFT

Testifying before the Defense Appropriations Subcommittee of the House of Representatives, recently, General O. P. Weyland, Commander of the Air Force's Tactical Air Command, said,

"In the research and development area, we should very soon be developing the airplane on paper, and so on, which will replace the F-105. This should be what we call a vertical or short take-off and landing airplane. We have very little money to put in on that, not enough to assure that the airplanes will come along at the time I feel they will be needed."

General Weyland explained that such an aircraft would eliminate a lot of the need for long concrete runways since they could operate from almost any site. It would also make deployment easier and, at the same time, lower the enemy's attack capabilities because he would need far greater numbers of weapons to knock the forces out.

BLOW-AWAY JET

(Continued from Page 7)

gravel and the other foreign objects that are found around most airports — nails, screws, nuts and bolts, bits of wire — also find their way into the interior of the jets, and can scar and pit the turbine blading.

The problem has been so serious to the Air Force that it maintains a continual training program to impress mechanics with the importance of keeping work areas clean near running jet engines. The Air Force has developed mammoth vacuum cleaners — similar to city street sweepers, but many times bigger — to keep airport runways clean. Many commercial airports now have them in operation.

Douglas Aircraft Company, for whom Ryan builds the engine pods and pylons for the DC-8 Jetliner, has gone two steps further to prevent turbojet contamination.

First, Douglas designed the air inlets so they contain no mechanisms requiring extensive repairs or adjustments. This practically eliminates the possibility of small parts, cigarette lighters, and other objects being left in the inlets where they might be drawn into the turbines.

Second, they've devised an ingenious method of preventing airport runway debris and foreign material from entering the volume of air that's sucked into the engine.

Exhaustive testing and investigation by Douglas engineers uncovered the fact that debris is not sucked up directly by the large volume of air entering the engines. Instead, the air being drawn into the engines frequently sets up a small vortex of air, a minature tornado, which rotates at high velocity and lifts damaging particles to the level of the jet intake.

To prevent the formation of this vortex, Douglas installed a blow-away jet just below the engine intake. This blow-away jet consists of a small amount of engine high pressure bleed air directed forward and downward. The jet of air carries to the ground and is spread in all directions with sufficient velocity to overpower any inward velocity induced by the engine inlet. This forestalls the formation of a vortex below the inlet and prevents any material from being sucked into the engine from the runway.

Normal operation of the blow-away jet is automatic, being actuated by the landing gear. It operates only during ground operations and shuts off when the airplane is airborne.

In over 700 hours of engine operation on the first D-8, no damage to the engines caused by ingestion of debris has been found.

FAST FREEZE

(Continued from Page 13)

bottom of the tank, from where it rises through the dry ice into the die.

Just as important as the quick chilling is the time saved, and the accuracy gained through revision of the method of die manufacture. Before the new method was installed, both die and punch were made of Kirksite from refrence patterns. The punch was subsequently laboriously and painstakingly matched to the die. In making a particular punch, the reference patterns might involve 30 manhours of work, the molding and casting of the punch 6 manhours, and the matching-up process another 60 manhours.

With the new method, a simple lead punch is used. The finish die is used as the mold, and the lead is poured into the die. This assures complete and accurate matching, and since the die doesn't heat during the quenching process, the lead punch doesn't melt during use.

The cooling cycle is required in many of the alloys used in high-speed jet-age aircraft. One particular alloy, 17-7 PH stainless steel, can serve as an example. Ryan uses tons of this material in building the pods and pylons for the Douglas DC-8 Jetliner.

Parts made of 17-7 PH are first formed from material in the annealed, or soft condition. A heat-treating process — known as the transformation cycle, makes the soft material extremely hard and brittle. A critical part of the transformation cycle is the time during which the metal is brought from an oven, where it has been held at 700°F, cooled in a finishing die to at least 80°F or lower, and then placed in a refrigerator. No more than 15 minutes are allowed to move the part from the oven, through the die, and into the refrigerator.

Before the introduction of the new process, a major stumbling block was the period during which the part was

(Continued on Next Page)

cooled in the die. The metal would give up heat to the die until it was no longer possible to chill the part in the time allowed. Work came to a standstill until the die had cooled to a point low enough to permit operations to resume.

With the new hollow-core dies and the portable cooling tank, the dies are kept cold, the part is chilled in about one minute, and the press remains in production as long as required.

NAVIGATION BY RYANAV

(Continued from Page 23)

airspeed indicator has installation errors and does not, in fact, indicate directly the true air speed of the airplane. Various corrections must be applied to obtain calibrated air speed—which is the reading displayed on the instrument face corrected for pitot-static tube installation error and minor instrument calibration error. The calibrated air speed is then further corrected by applying existing temperature and pressure altitude. Only then is the true air speed found. This system takes time, and has more than enough chances for error built into it.

And aircraft are much more susceptible to side movement caused by wind action than surface vessels. Thus the drift-meter, in its simplest form a grid of parallel lines installed in an opening in the floor of the airplane, must be used to keep on course.

This isn't to say that a commercial airliner can easily get lost or stray too far from its destination. Too many aids —TACAN, VOR, for example—help the pilots of today's passenger liners arrive at their expected destinations on time. There's another facet to the problem, though. The new jet-powered planes fly so fast that time is becoming critical. For purposes of traffic control and profitable management, a pilot should be able to report his position instantly and accurately.

The problem is more serious with military operations. The bomber pilot can't expect to be guided to his target by the enemy's radio aids, and celestial navigation is just too time-consuming.

Military and commercial aviation share another problem. In addition to the errors built into the mechanical aspects of the aviation navigation systems, the human part of the system is subject to fatigue and error. Also, the presence of the human navigator detracts from payload or range. Payload isn't quite so critical when you're carrying thermonuclear weapons. But range is liable to be, and while range may not be a problem when you're carrying fuel reserves of 50 per cent, the loss of a $650 seat across the Atlantic can amount to a substantial sum of money at the end of a year's commercial operation.

Fortunately, the solution to commercial navigational problems is available in Doppler navigation systems. Doppler can guide a plane across the Atlantic with a navigational error of perhaps ten miles, and do it without reference or assistance from any systems outside the airplane.

The RYANAV* Model 120A, for instance, functions without the aid of ground stations or wind estimates. It works in any weather, is completely self-contained, and provides — automatically, continuously and accurately — ground speed, drift angle, ground position, ground track, wind speed and direction, course and distance-to-destination, and aircraft altitude and heading.

It does away with—in certain applications—VOR equipment, turn and bank indicator, directional gyro, artificial horizon, and existing heading and vertical references.

More important, it does away with the old celestial navigation system and its various instruments, with their built-in errors. No more octant, with its error-prone bubble; no more drift meter; no more necessity to compensate for various instrument errors.

With the RYANAV navigational system, the pilot steps aboard, cranks in his present position, sets in desired latitude and longitude, and takes off. The little black boxes keep an eye on the proper air speed, ground track and drift angle, and give the pilot a continuous reading on present latitude and longitude. The system also computes course-to-destination and distance-to-destination.

The RYANAV Model 120A includes a contact analog display device. This Dead Reckoning Position Indicator shows present position and heading as a lighted aircraft silhouette on a translucent screen marked with a scaled coordinate grid and a circular heading scale. The integrated flight instrument is a single display indicating the pitch angle, roll angle, turning rate, and heading of the aircraft.

RYANAV systems are small, lightweight, and not subject to either mechanical error or human fatigue. Their impact upon world aviation is gathering the momentum of an important navigational break-through.

**Trademark*

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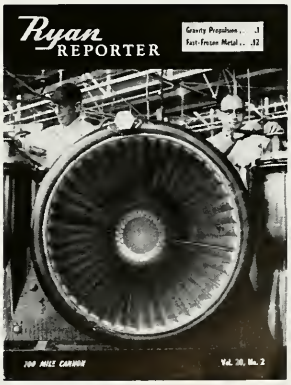
ON THE COVER

Unique view of fuel orifices and nozzle of Ryan-built rocket motor for Army's Corporal missile. Jim Sherbundy (left) and J. H. Smith check other units. (Gossett Photo).



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NAVY SELECTS RYAN C-W DOPPLER NAVIGATORS FOR MAJOR AIRCRAFT

Six major types of Navy aircraft will be equipped with Ryan continuous-wave Doppler navigation systems, the AN/APN-122 (V), under an initial $20-million contract awarded by the Navy to Ryan's Electronics Division. Ryan's automatic, all-weather, self-contained navigators will be installed in the Navy's Lockheed Neptunes (P2V), Martin Marlin patrol planes (P5M), carrier-based Douglas Sky Warriors (A3D), and three types of Grumman aircraft.

Developed in cooperation with the Navy, these advanced electronic systems are the lightest, simplest, most compact, and most reliable of their type. The new order, one of the largest of its kind, emphasizes Ryan's leadership in navigation and guidance systems.

With a solid backlog of this and other important contracts for RYANAV systems, the Ryan Electronics Division is growing even faster than this fastest growing industry. Personnel and facilities are being doubled, both in the new production plant at Torrance, Calif. and at the San Diego facility, where a modern new electronics research center is under construction.

New electronics production facility at Torrance (near Los Angeles).

New electronics research center at San Diego.

Ryan's rapid growth in electronics is creating new opportunities for engineers and technicians

Ryan REPORTER

Sub Killer Doppler . . . 1
300,000 psi Steel . . . 8

VOL. 20, NO. 3

ANTI-SUBMARINE DOPPLER

Ryan electronics systems guide Navy hunter-killer teams

Alone, alone, all, all alone;
Alone on a wide, wide sea.
Samuel Taylor Coleridge
The Ancient Mariner

BEING alone, all, alone on a wide, wide sea may have seriously distressed the Ancient Mariner, but such a condition is a comfort and a solace to those who roam the oceans in submarines. And the submariner's ability to be alone through his choice is a source of considerable annoyance to this nation's anti-submarine warfare task forces.

Ryan, however, is helping to lessen this ability by contributing navigation devices, and a wide variety of airframe and engine components for the aircraft that hunt down subs.

Finding a sub that wants to be alone is a tough job. The sub has nearly 330,000,000 cubic miles of ocean in which to hide (not counting navigable rivers), and can move from hiding place to hiding place while still staying hidden. Yesterday's subs had to surface from time to time to charge their batteries and fix their position. Today's nuclear-powered subs can stay submerged while journeying from continent to continent — as the Nautilus and Skate have repeatedly demonstrated, and, with inertial guidance, the need to peek to fix position is gone.

There's another problem to be solved before you can go about blasting a sub. Make sure it's a sub. Whales and schools of fish have been known to act more like a submarine than a submarine does. Sub-hunters have been fooled by folds in the ocean floor, by subaqueous mountain peaks, and even by variations in water temperature.

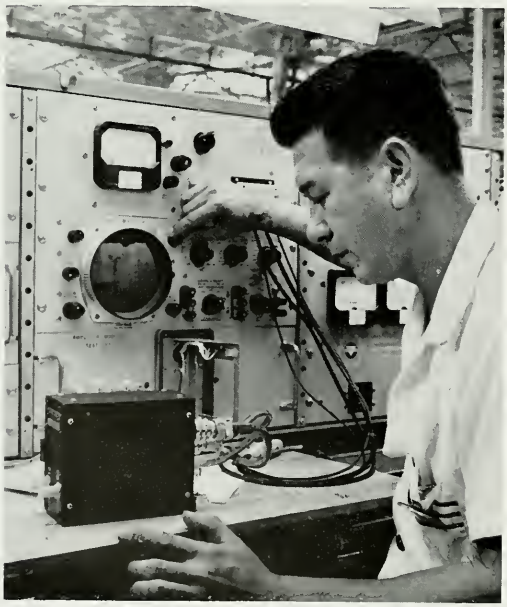
It's no secret that the Navy considers that there is not now an adequate defense against the nuclear-powered submarine. The ability of the sub to choose to be alone

(Continued on Next Page)

RYANAV*-equipped S2F-1 Trackers, MAD gear extending from tail, "buzz" "enemy" submarine after "kill" during ASW exercises.

**Trademark*

Destroyer speeds beside carrier for refueling as Tracker returns from contact. Hunter-Killer Group can stay at sea indefinitely.



Ryan technician Ben Bondshu finds RYANAV component in perfect working order during checkout of navigation equipment.

has grown in great leaps since the closing days of World War II, when a sub was sunk for every ship that was sunk. The secret of the successful sub-hunting of those days was the aircraft search. When the sub surfaced, the planes picked him up on radar or by sight, and a sighted sub generally was a sunk sub.

Today, the sub can stay submerged for a long time, and today's tools of search are sonar, magnetic anomaly detectors (MAD gear), and electronic intercept equipment, which detects submarine radar signals.

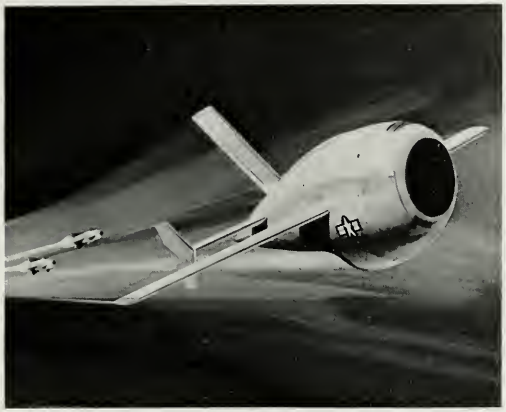
Sonar—SOund NAvigation Ranging—can be either "active" or "passive." In either case, it has limitations. Sea water can be quite an effective dampener of sound waves, and the sea contains fish, animals, flora, and elements of topography that can thoroughly confuse the most experienced sonar operator. Variations in sea water temperature and density work against sonar, and especially sharp gradients in temperature can bounce back sonar beams as effectively as any sub. In fact, subs can, and do, hide beneath these layers. And, if that isn't enough, the "silent" sea is about as silent as a zoo just before mealtime. Fish boom, shrimp snap, moans come from whales, porpoises squeal — about the quietest thing in the "silent" ocean is the sub you're trying to locate.

MAD gear has some drawbacks, too. It detects submarines by the disturbance caused in the earth's magnetic

(Continued on Page 37)

PROJECT "WILLIAM TELL II"

Tyndall Air Force Base, Florida
October 14-23, 1959



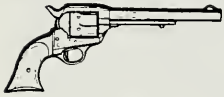
Ryan Firebee jet targets have been selected for the second consecutive year as the exclusive targets for the 7th Worldwide Weapons Meet of the Air Defense Command.

The fast, free-flying, remote-controlled Ryan targets came into their own during last year's Project "William Tell I," described by high-ranking officers as the "toughest challenge to combat proficiency ever put to test."

The challenges will be even tougher this year. Interceptor pilots will be asked to fly new intercept tactics, including new angles of attack, new angles of interception, and new types of team work. In addition to meeting one Firebee in broad daylight, they'll be challenged by Firebees in formation, and by Firebees flying at night.

The Firebee will be hunted down by Northrop F-89F Scorpions, firing Douglas MB-1T Genie (atomic-type) rockets; by Convair F-102 Delta Daggers firing Hughes GAR-1D and GAR-2 Falcons; and by Lockheed F-104 Starfires and North American F-100 Super Sabres firing GAR-8 Sidewinders.

This year, electronic scoring will again be used. All Firebees will be fitted with the PARAMI scoring system.



OPERATION "TOP GUN"

MCAAS, Yuma Arizona
Nov. 30 - Dec. 4, 1959

Ryan Firebee KDA-4 jet targets have been selected as the only free-flying jet targets to be used at Operation "Top Gun," the Fourth Annual Naval Air Weapons Meet, to be held in Yuma, Arizona, November 30 to December 4.

Operation "Top Gun" will be held at the Marine Corps Auxiliary Air Station at Yuma, but firing of Sidewinders — the Free World's most widely used air-to-air missile — from Navy fighter planes against the Firebees will be performed in gunnery ranges over the ocean off the San Diego coast. Utility Squadron Three at Brown Field, Otay Mesa, San Diego County, first Navy unit to receive the KDA's, will operate the speedy, high-flying targets by remote control.

Forty-four of the Firebees are presently being modified at Ryan's Torrance, California, plant. Modifications include painting the jet target with fluorescent "Dayglo" paint to increase daytime visibility; and installation of radar tracking beacons and heat-emitting flares.

Worldwide competition among the Navy's top fighter-interceptors is now going on. Winners will be pitted against the Firebee to determine the "Top Guns" of the U. S. Navy.

High performance Q-2C Firebee, framed in B-26 launch plane window, streaks out under own power. Bob Todd is Ryan controller.

PUSHBUTTON TARGETS

Record-setting Ryan Q-2C Firebees roll into production under Air Force contracts

Q-2C GOES INTO PRODUCTION

With the recent award of Air Force contracts totaling $8,667,000, the Q-2C Firebee has gone into production under a program which will extend well into 1960. In addition, negotiations will be undertaken for orders of more than $2½ million for spare parts, ground support equipment and other related items. More than $14 million in orders have been awarded Ryan by the Air Force for work on the new Q-2C, including the first group of experimental models and the product improvement phases.

Streamlined new Firebee nosed to 59,800 feet to set new altitude record. Ryan crewman Rex Howard makes ground check.

WHAT is our chance for survival if an enemy attacks us from the air?

The answer is simple. Our survival still depends on whether the enemy gets through our air defense system to dump his lethal charge.

To see that we do survive, our government possesses the farthest seeing "eyes," the fastest scrambling interceptors and the deadliest batteries of bomber destroying missiles in the world.

If this country is attacked by air, the first shots fired in defense may well be a salvo of rockets or missiles unleashed by a young man flying many miles above the earth in a modern jet interceptor. The effectiveness of the salvo will depend on how well, how realistically, he has been trained. His training, a responsibility of the Air Defense Command, depends on how realistic the "stand-in" for the enemy is during air defense rehearsals.

Q-2C test models were precision built in Ryan engineering shops. Ryan painter Lloyd Varney inspects glistening finish of nose section.

The stand-in? The Ryan Q-2C Firebee jet target missile, an advanced target system whose first models are now in category "one" of a three-phase flight test program at Holloman Air Force Base, New Mexico.

Versions of the Firebee have tested the effectiveness of nearly every weapon and weapon system in the nation's defense arsenal for the past 8 years and are the most widely used high performance target system in the Armed Forces. Firebees are in service with the Air Force, Navy and Army, and the Navy configuration of the Firebee is currently in operation with the Royal Canadian Air Force.

However, as higher-altitude, higher-speed aircraft were phased into operation, a new higher performance Firebee was needed to test the effectiveness of these new manned and unmanned weapon systems.

The Air Force asked for the new higher performance target in February 1958, inspected a prototype in October 1958, and observed the first test flights of the XQ-2C in December 1958, at the Holloman Air Force Base site.

An improved design from streamlined Fiberglas nose cone, through swept-back wings to enlarged parachute container, the Q-2C incorporates all the target missile know-how accumulated at Ryan in nearly ten years of research, development and production.

(Continued on Next Page)

Q-2C's electronic brains are covered by a one-piece access door. Compartment features black boxes set on pull-out racks.

Ryan technician John Deegan checks out sleek target with Ryan-designed ground service cart which has cut ground time to bone.

In just over 30 flights, the XQ-2C has surpassed Air Force requirements and claimed world's altitude and duration-at-altitude records for jet target missiles. It has achieved a radar-measured altitude of 59,800 feet and flown for 77½ minutes above 50,000 ft. in a single flight. It has achieved a maximum single flight duration of 96.8 minutes and regularly demonstrates speeds of Mach .95. One target has completed eleven flights without a major overhaul.

Under the Q-2C's sleek red shell, a complex electronic heart, made up of several interconnecting "black boxes," gives the target a high rate of maneuverability. A small "box" in the aft section of the enlarged equipment compartment, termed the "Altitude Air Speed Switch," is the "thinking target's filter" — the heart of the high performance electronic flight control system. It relays signals to other systems in the missile, passing on air speed and altitude information which triggers other switches to set off a chain of automatic operations. The new automatic reaction characteristics of the various electronic components tends to simplify the remote control of the Q-2C.

Reactions of the target missile are so-near automatic that it will climb or enter a descending glide pattern if parachute recovery conditions are adverse at the time of engine shut-down.

Ron Reasoner, Ryan Q-2C project engineer, explains

Ryan-designed, light-weight parachute streaks from aircraft in dummy load test. Taped seam parachute is 81.6 feet in diameter.

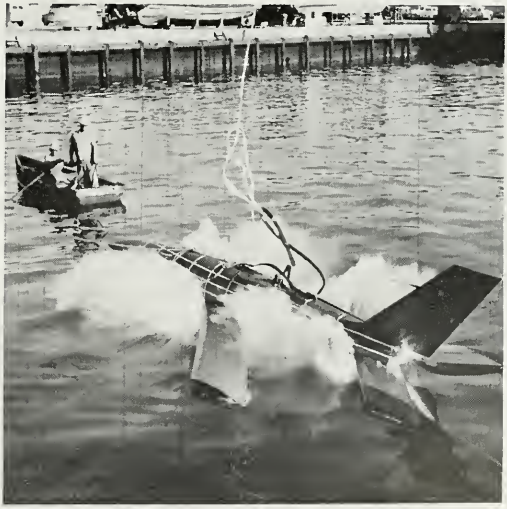
The Q-2C (left), bigger than the Q-2A (right) is launched from the B-26 at 15,000. Q-2C will climb to 50,000 feet in seven minutes.

the target's reactions. "After the mission is completed, if the target is cruising along at the base of its operating envelope — 300 feet — and the engine shuts down from fuel depletion or other cause, the Firebee, through the action of the altitude air speed switch will enter a climb, utilizing its kinetic energy. The bird will continue to climb until it reaches a more desirable altitude and air speed, then the parachute will eject — automatically — for recovery."

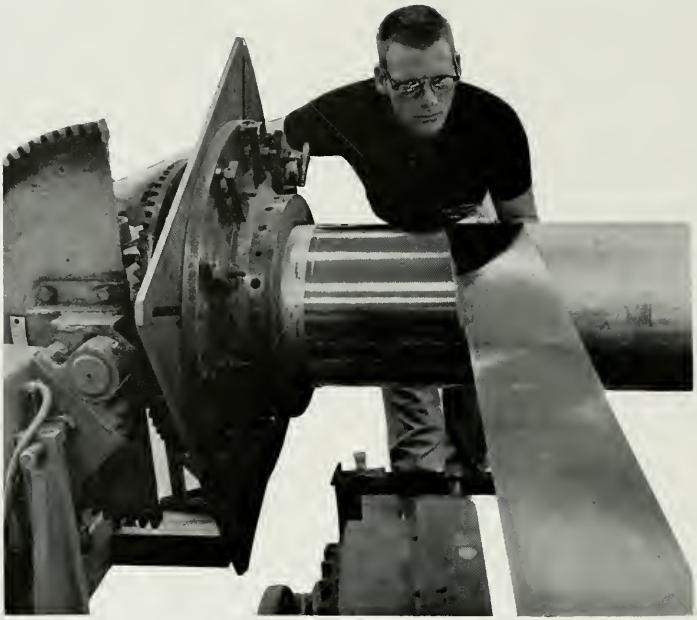
Reasoner explained further, "The Q-2C's reaction is the same, in case of engine shutdown at high altitude. The target will automatically enter a glide pattern until it reaches a desirable air speed and altitude for recovery which will not blow a hole in the chute and expend the target."

The target's high rate of climb can also be attributed to the reaction of the complex electronic equipment. When cruising at any given altitude, the Q-2C can be commanded to climb — "and climb it will — right now" Bill White, project assistant engineer states. The target will automatically adjust its control surfaces as it climbs, to negate any stall characteristic encountered in the steep climb attitude.

(Continued on Page 35)



Firebee makes big splash in water drop tests in San Diego Bay. Extensive flotation tests surpassed Air Force requirements.



Super-strength steel, tissue-paper thin, spirals slowly onto mandrel, where it's tack-welded into position. Ryan engineer W. E. Clark keeps watchful eye, sure hand on job.

SUPER-STRENGTH ROCKET CHAMBERS

Ryan rocket chambers of foil-gage steel withstand test pressures of 305,000 psi

EXTREMELY strong rocket chambers, capable of withstanding 305,000 psi wall stress, have been built by Ryan, using paper-thin steel and unique spotwelding techniques. Light weight has been achieved by a "strip-winding" method in which multiple layers of foil-thin steel strips are spotwelded together.

Ryan has built and tested a variety of quarter-scale rocket motors and is adapting this research — in which strengths much higher than those achieved in solid wall cylinders have been realized — to full-scale rocket motor requirements.

Obtaining this high strength required the solution of major problems. One which was successfully overcome was the reduction of stress concentration around the spotwelds through improved spotwelding techniques. Ryan welding engineers spotwelded together as many as twenty layers of thin gage material.

These new spotwelding techniques have enabled Ryan engineers to overcome a major hurdle in the construction of the rocket chambers, that of attaching end closures. End closures, of 17-7PH stainless steel, were welded in place with the new Ryan method, and successfully withstood the 305,000 psi stress.

In addition to the utilization of stainless steels, Ryan will build at least one sub-scale model chamber of titanium alloy, a metal with which the company has had considerable experience.

The Ryan technique of spotwelding together many layers of foil-gage stainless steel alloy is the best method of containing the explosive force — measured in hundreds of thousands of pounds—which is developed in rocket motors. Two methods have been tried, and neither seems suitable. Brazing the layers together introduces extra weight, and temperatures high enough for good brazing weaken the parent metal. Resin bonding of the layers doesn't work well, since the layers separate when confronted with the high temperatures associated with aerodynamic heating.

Ryan carried on an extensive search for a material that would meet all the conditions to be found in the construction of these chambers. Metals tested included 17-7PH stainless steel, 301 Extra Full Hard, AM355 Sub-zero Cooled Cold Rolled and Tempered stainless (in both the 30% and 70% Cold Reduced types), HE-25, PH15-7Mo, and AM355 Cold Rolled and Tempered. Presently being tested is AM355 Cold Rolled and Tempered Extra Hard, which was unavailable when the other metals were being examined.

Two-ply spotwelded specimens were made from each of these alloys. Specimens ranged in width from .300 inches to .750 inches and the number of spotwelds varied from one at the center of the strip to overlapping spots across the entire width.

Testing included determination of parent metal yield and ultimate strength. Young's modulus and per

(Continued on Page 10)

Gleaming interior of finished rocket chamber forms a frame around Ryan weldor R. C. Rozelle as he fires welds into another case.

cent of elongation, ultimate strength reduction due to spotwelding, and a strength-to-weight comparison, which was determined by dividing the ultimate strength by the material density.

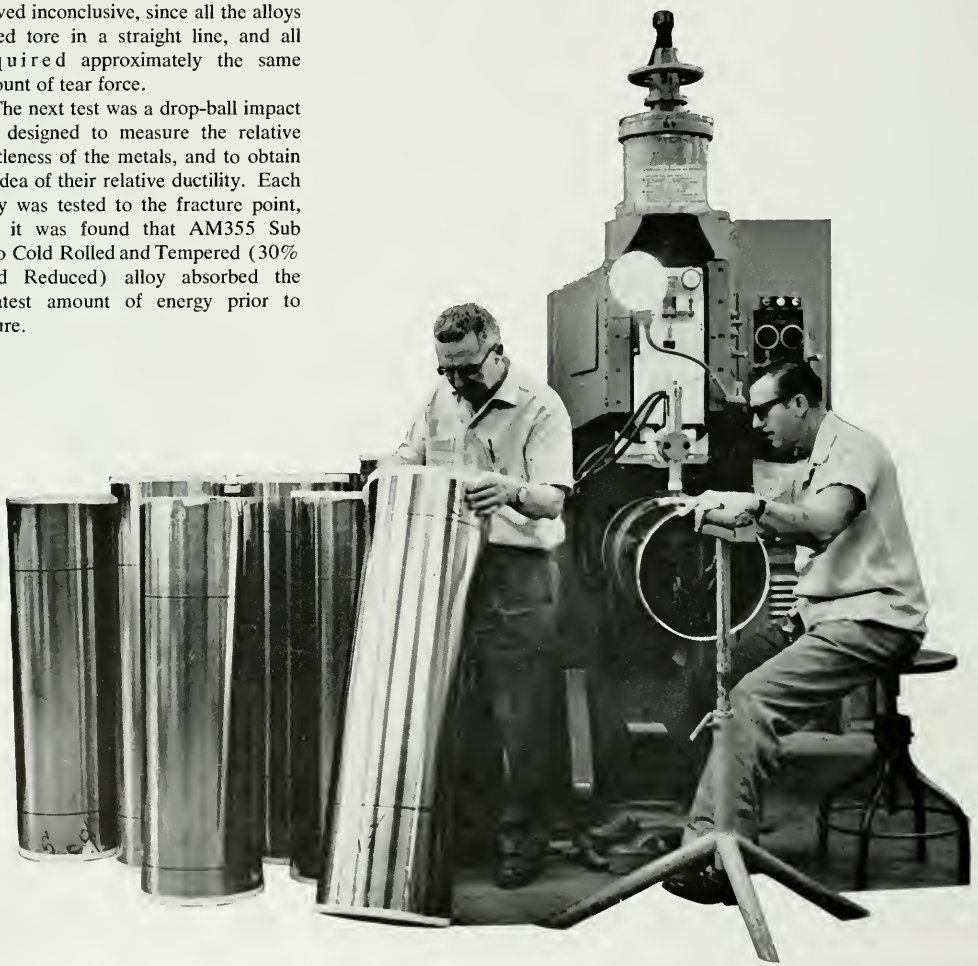
It was found that these tensile tests, by themselves, were not enough to warrant elimination of any one of the metals. A tear test of the various materials was then made. There is a correlation between the type tear, the tearing force, and the ability to predict ultimate load on a laminated structure. A straight line tear, rather than a jagged line, plus a high tearing force are desirable qualities. This test also proved inconclusive, since all the alloys tested tore in a straight line, and all required approximately the same amount of tear force.

The next test was a drop-ball impact test designed to measure the relative brittleness of the metals, and to obtain an idea of their relative ductility. Each alloy was tested to the fracture point, and it was found that AM355 Sub Zero Cold Rolled and Tempered (30% Cold Reduced) alloy absorbed the greatest amount of energy prior to failure.

One further test involving all of the metals under consideration was made. Brittle fracture characteristics of each type were determined with the aid of the Mechanics Division of the Navy Research Laboratory.

When results of these five tests had been obtained, four metals could be initially selected; HS-25, AM355 SCCRT (both 30% and 70% CR), and AM355 CRT. Because of its density, HS-25 was eliminated, and AM355 SCCRT CR 30% was eliminated because of its relatively low tensile strength. Subsequent testing effort was concentrated on AM355 CR 70% and AM355 CRT.

Research is now in progress in an effort to raise the 300,000 psi ultimate allowable tensile stresses of laminated structures made of the AM355 series of alloys. This research centers around the modification of resistance welding techniques, including electrode shape and material, current density and wave shape, and weld nugget size.



Ryan Engineer L. E. Leech inspects rocket chambers ready to take 305,000 psi test pressure as Rozelle "stitches" new case together.

RYAN READIES VERTIPLANE

Army VTOL research plane to resume flight testing at Moffett Field

THE Ryan Model 92 Vertiplane, now undergoing modifications and repair in San Diego on authorization of the Office of Naval Research, will resume flight testing at the Moffett Field Naval Air Station, San Francisco, in late August or early September, William T. Immenschuh, Ryan Engineering Manager of Test Operations has announced.

The Vertiplane, a VTOL/STOL research aircraft for the U. S. Army, was damaged on its 13th test flight on February 13 because of a malfunction in the propeller control system.

Although complete transition from horizontal to vertical flight had not been made prior to the mishap, the Vertiplane had flown in excess of 5,500 feet altitude, speeds over 110 knots and as slow as 26 knots. Approximately 170 hours of various ground and wind tunnel tests had been successfully completed in the program in addi-

(Continued on Page 30)

Ryan mechanics George Bowie and John Stewart install modifications to Vertiplane suggested in first phase of flight testing.

The Navy's Mighty Midget, the Douglas A4D Skyhawk, dangles tail hook as it slams onto carrier deck at end of mission.

COMPACT, LIGHTWEIGHT, automatic navigators which provide a true all-weather navigational capability for light attack and fighter aircraft have been developed by the Electronics Division of the Ryan Aeronautical Company. This navigation system has already undergone flight testing in the Douglas A4D "Skyhawk," the Navy's high-performance carrier-based light attack bomber.

The new equipment constitutes a further development of the RYANAV* AN/APN-122(V), for which a large production contract was recently received from the Navy. The system is suitable for installation in a variety of aircraft including Aircraft Early Warning (AEW), Anti-Submarine Warfare (ASW), interceptor and fighter-bombers.

The AN/APN-122(V) was installed in the A4D at the Naval Aviation Ordnance Test Station at Chincoteague, Virginia and initially flight checked at Miramar Naval Air Station, San Diego. It is now undergoing operational evaluation with squadron VX-4 at the Naval Air Missile Test Center, Point Mugu, California.

SHARP "EYES"

RYANAV-fitted Skyhawk and Navy-Ryan test team of Navy Lt. Donald K. Forbes, Ryan engineers Chas. Bates (l.), Robt. Price. Arrows point to telephone-sized antennas buried in plane wings.

One important result of the program is the vastly increased capabilities of fast carrier-based attack bombers, enabling them to range far at sea in any kind of weather. The pilot is automatically provided with his position fix, and course and distance to his destination. The over-all effectiveness of the aircraft is increased considerably since offensive operations can be flown around the clock.

The AN/APN-122(V) is a self-contained navigational system which employs continuous-wave Doppler radar. The equipment uses two fixed beams of radiation, which are directed downward and ahead of the aircraft's line of flight.

The AN/APN-122(V) automatically and continuously computes and displays ground speed and drift angle without the aid of ground stations, wind estimates or true air speed data. Outputs are provided for tie-in with ground position computing and indicating equipment, course and distance computing and indicating equipment, inertial navigation equipment, bomb director sets, ASW sets, and terrain clearance radar. This versatile system can be used in conjunction with integrated flight systems, automatic pilot, and flight director systems for very low as well as very high altitude aircraft.

A 28-volt signal is provided by the system in the event of Doppler loss, radar equipment failure, or radar silence. This signal provides for "memory" of last known ground

speed and drift angle, and is also available for use by associated navigational computers, which may include wind-memory provisions.

The AN/APN-122(V) measures ground speeds from 80 to 800 or 1000 knots and functions at all altitudes from 0 to 70,000 feet.

One major problem inherent in the design of automatic navigation equipment for compact aircraft such as the A4D is the very limited space for location of component parts. Nearly every inch of the sleek aircraft is occupied with complex gear necessary for its assigned mission. Ryan engineers, working in close cooperation with the Navy and Douglas Aircraft Company, were able to devise an ingenious, satisfactory solution.

The biggest task was that of the antenna location. Previous designs had proved impossible to install in the space available. Normally, the antennas used on all Ryan-manufactured Doppler navigators are formed into a single, compact unit and are an integral part of the receiver-transmitter. Its function is the simultaneous transmission and reception of radar energy.

By splitting the receiver-transmitter, the engineers were able to physically separate the two portions of the unit, so that it now resembled two telephone handsets. They were then mounted individually directly inboard of the main landing gear wheel wells.

From a pilot's viewpoint, the use of the AN/APN-122(V) on a mission might typically begin in the ready room of the aircraft carrier immediately prior to launch. The latitude and longitude of the assigned target would be pin-pointed, in addition to the ship's present position. He would also receive information as to the future location of the ship when the aircraft is due to return.

The pilot "cranks in" the latitude and longitude of his present position and that of his target on the navigational computer indicator, along with the ship's future position.

The computer then "memorizes" and stores this information for use on the return flight to the ship. The pilot flies outbound, with the bearing and distance indicator

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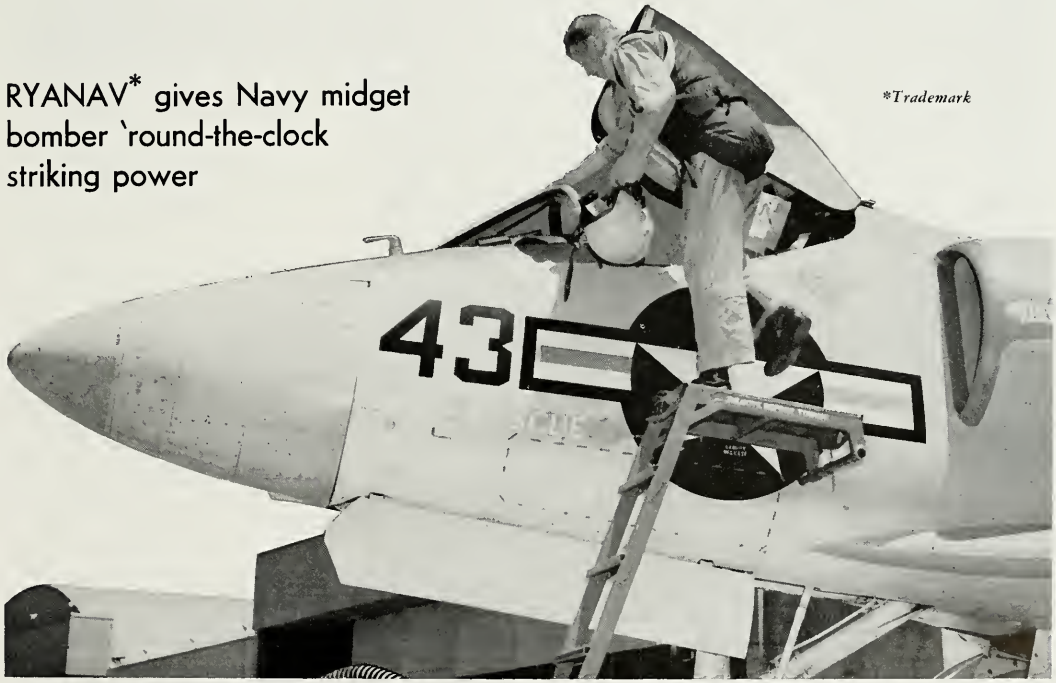
FOR THE SKYHAWK

RYANAV* gives Navy midget bomber 'round-the-clock striking power

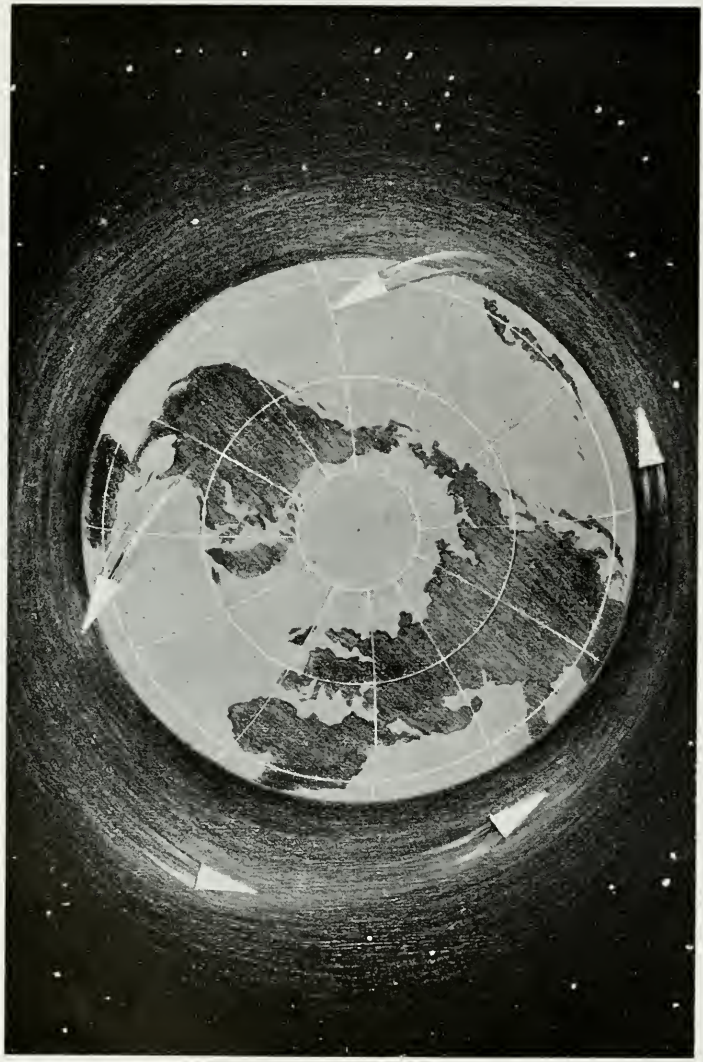
**Trademark*



Lcdr. R. E. Mosely, Navy Project Officer on RYANAV-A4D Skyhawk program, climbs aboard Mighty Midget for an evaluation flight.

MiniWate IN NEAR-SPACE

Ryan awarded USAF study contract for high-altitude vehicle structures



Artist's concept of feather-heavy space vehicle of unique design, using Ryan MiniWate structure and unique propulsian, which circles the earth at high altitudes.

RYAN engineers have begun studying the application of MiniWate* to a vehicle capable of operating at extremely high altitudes, under a contract from the Air Force. The contract was awarded by the Fluid Dynamics Branch of the Air Force's Aeronautical Research Laboratory, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio.

Details of the near-space craft or its mission have not been disclosed, although it is expected to operate at extreme altitudes in an effort to determine environmental conditions affecting the functioning of unique propulsive devices.

Ryan has been assigned the task, over the next eight months, of determining the feasibility of producing a structure that will be adaptable to this type of vehicle. Various materials will be tested from the standpoint of efficiency and availability. Ryan's extensively equipped environmental test laboratory and materials and process engineering laboratory of the Engineering Division will be among facilities used in the research program.

MiniWate is a Ryan design concept, applicable to any weldable metal. It is made of foil-gage sheet metal, resistance welded to extremely thin corrugated sheet. The result is an extraordinarily strong, light-weight, heat-resistant metal structure. Unlike other light metal techniques, such as brazing, which introduces unwanted weight, and resin bonding, which cannot withstand the high temperatures associated with aerodynamic heating, MiniWate adds neither metal nor resin, can stand extremely high temperatures.

MiniWate was developed by Ryan structures engineers, metallurgists and production experts in a four year re-

(Continued on Page 35)

**Trademark*

Ryan Firebee jumps for altitude with assist from rocket motor in eorly Air Force experiments ot Holloman Air Force Base, N. Mex.

FIREBEE GROUND LAUNCH

Ryan receives Army contract to develop Firebee ground launch system

RYAN'S famed, fast-flying target missile, the Firebee, will soon be given additional duties. The U. S. Army, which recently tested its Nike-Hercules against the Firebee at Fort Churchill, Canada, has awarded Ryan a contract to develop a "zero-length" launching system which will enable the Army to send up Firebees from various locations to provide realistic targets for evaluation of the Army's surface-to-air missile systems.

These missile systems are becoming increasingly sophisticated, and the propeller-driven drones—usually surplus aircraft from the days of World War II—are too slow to adequately test the efficiency of today's weapons. The Air Force turned from its towed targets when it selected the Firebee as the exclusive target during Project "William Tell," a world wide weapons meet held at Tyndall Air Force Base, Florida, in October, 1958. The Firebee will play the same role during "William Tell II," to be held at Tyndall in October, 1959. The Navy, too, has selected the Firebee as its free-flying "enemy" when it holds its weapons meet at the Marine Corps Auxiliary Air Station in Yuma, Arizona, November 30, 1959. Called Operation "Top Gun," the Navy will send its best pilots and its hottest fighter interceptor planes against the Firebee.

Since the first Firebee took to the air, the military services have fired just about every weapon in the defense arsenal against the elusive target. Fifty-calibre machine guns, three-inch anti-aircraft batteries, Sidewinders, Genies, Falcons, Nikes, Mighty Mouse rockets,

(Continued on Page 31)

Nose cowls gleam in glistening new Ryan final assembly building where Inspectar R. C. Eaton (l.), Asst. Foreman J. H. Farrell confer.

PRECISION BUILT PODS

Ryan puts new metals, ideas, facilities to work to package the power of 16 locomotives in DC-8 pods and pylons

TWO of the oldest and most respected manufacturers in American aviation — Douglas Aircraft Company and Ryan Aeronautical Company — have successfully demonstrated that new tools, in new buildings, used with new techniques on new metals, can be combined with decades-old skills and precision in manufacturing to produce fine modern-as-tomorrow airplanes.

For one of these new airplanes, Ryan now builds pods and pylons. These titanium, stainless steel and aluminum structures grace the DC-8, the latest in a long line of highly successful commercial transport planes of Douglas design.

The Douglas DC-8 program is an important part of Ryan present-day business. The project consumes nearly ten tons of titanium each month, has dictated the building of a unique assembly building, and has developed dozens of new ideas and techniques in material handling and aircraft parts production.

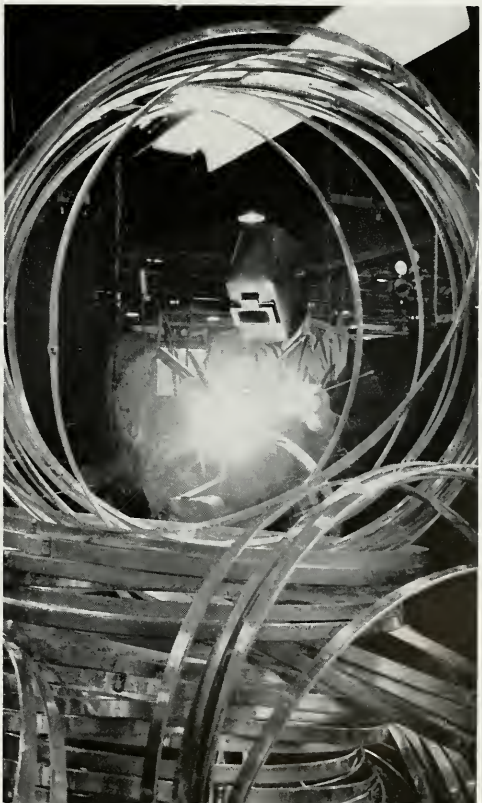
One example of the unusual in aircraft parts production is the use of explosive forming at Ryan to produce parts for the nose cowl on the DC-8 pod. A part that formerly was made of five separate parts formed on presses, welded together, ground and drilled, is now formed in seconds with a small charge of explosive. The part once cost $135 to produce. Ryan now makes it for $15 with explosive forming.

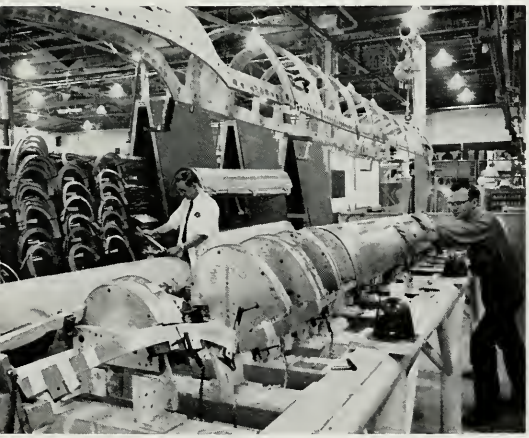
In a successful effort to meet the exacting tolerances demanded by the Douglas specifications — especially in reference to titanium — Ryan installed a battery of hot presses, built to Ryan standards and designs. Application of hot sizing techniques, using these giant machines,

(Continued on Next Page)

Ryan-built pod juts forward from giant swept-back wing of first United Air Lines Jet Mainliner. Four more Ryan-built pods power the first Douglas Jetliner as it speeds overhead.

Seventeen years of experience at Ryan in the skilled welding of aircraft parts are behind the sure hands of welder G. G. West as he completes stainless steel firewall attaching ring.





Precisely shaped part gets a close tolerance fit on a jig by Assembler A. E. Hansen as Asst. Foreman W. E. Hutchins checks a part on unique "erector-set" and pegboard part storage rack.

Ryan assembler J. E. Brennan puts final twist on nut in gaping "jaws" of pylon as J. Miramontez wheels another assembly into place.

Accurate engine build-up for airlines using DC-8 is insured by these parts-filled boards, being readied here by Asst. Supr. C. E. Zumwalt and B. L. Orozco, E. M. Jacobsen, C. G. Fordem.

Water geysers from Ryan explosive forming pit where DC-8 nose cowl part is made. Method permits high degree of accuracy, cuts cost of production to one-tenth of conventional method.

formed the tough metal to precise shapes and eliminated the spring-back tendency inherent in titanium structures.

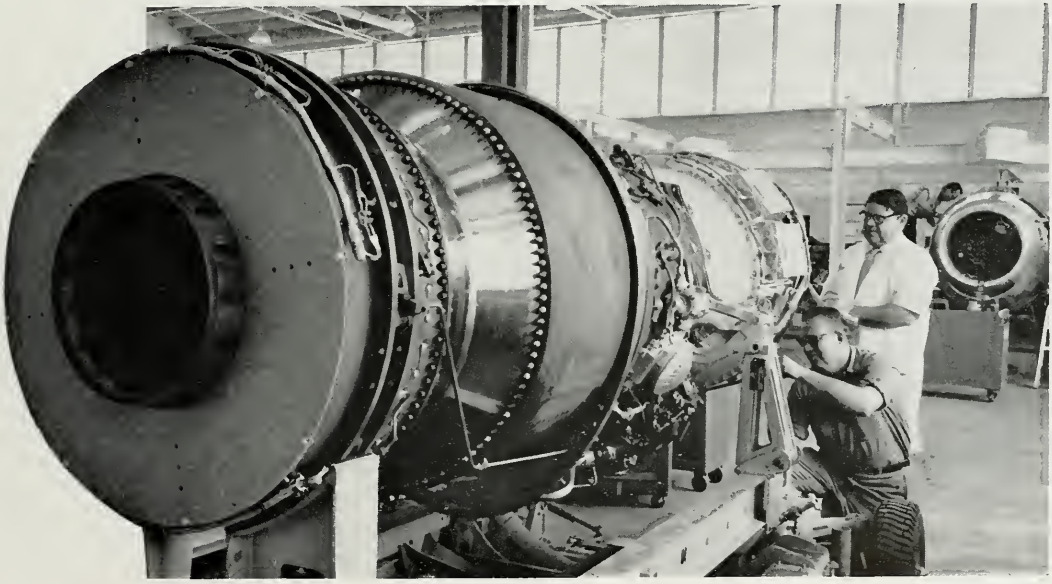
Ryan's new assembly building is the focal point of all the various sub-assembly lines throughout the Ryan plant. Designed especially to bring all parts of the pod and pylon program—with the exception of the access doors—together in a common finishing and shipping point, the building, with its 30,000 square feet of working area, affords a space where precision parts can be accurately and quickly assembled, and where highly critical inspection can be readily accomplished.

Inventions in metal working have been patented by Ryan as an indirect result of the DC-8 program. In one instance, some delay was being experienced in one stage of the heat-treating of stainless steel parts for the pylons assembly. These parts required final shaping in a die, while the part was at a temperature of 700°F. The part was cooled in the die to about 80°F, and then moved to a refrigerator. As the die absorbed heat from the part being shaped, the time required to cool the part became successively longer, until the part remained out of the heat-treating cycle for too long a period.

Ryan engineers eyed the problem, came up with a solution in the form of a new invention in the field. The die is now made hollow and super-cooled dry air is forced through it. The die remains cold, the metal is shaped and brought down to the proper temperature in one-twentieth the time formerly required, and the DC-8 program remains on schedule.

Careful spotwelding securely fastens together corrugated and smooth sections of DC-8 nose cowl inner shell. Ryan Foreman R. K. Grass (r.) checks skilled workmanship of H. E. Fisher.

"Bare-bones" engine is readied for installation in Ryan build-up gantry by Ryan's G. F. Wendt and Foreman Ray Cleveland (r.).



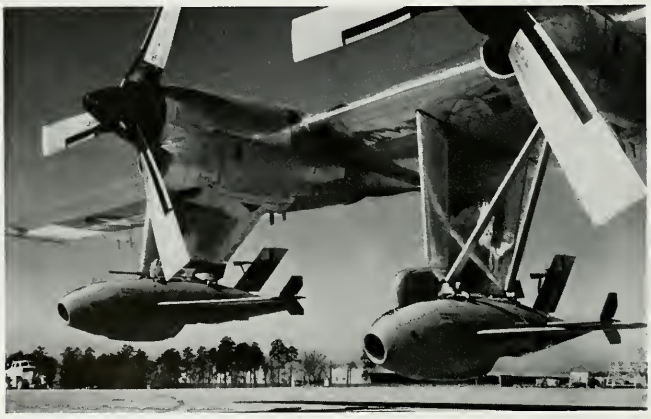
THE new Q-2C Firebee jet target missile will have an equally new "mother," when the Lockheed GC-130A Hercules becomes an operational launch plane for the Ryan target missile. Although Firebees will continue to be launched from the modified B-26 at a maximum altitude of 15,000 feet, the Lockheed Hercules will be capable of carrying four Firebees to 30,000 feet before effecting a launch. The added altitude will not only give the Firebee more time on station, but the increased on-station time of the Hercules will allow it to launch a Firebee, retire to a safe distance from the range while fighters detect and intercept, and then return to the range to launch another target.

Lockheed Aircraft Corp. and Ryan are jointly developing the new aerial launching system for the Firebees.

The Hercules, modified to carry four Firebees — twice as many as presently carried by the B-26 — has made successful first flights from Dobbins Air Force Base near Marietta, Ga., with a brood of Firebees nestled under its wings.

FOUR AT A TIME

Giant Lockheed Hercules will launch four Firebees above 30,000 feet



Like a huge aerial "trapshooter" airplane, the Lockheed GC-130A Hercules will carry twice as many Ryan Firebees and air-launch them twice as high as present "mother" planes. Result: Extended "on-range" time for Firebee jet targets.

Designated the GC-130A Drone Launcher/Director, the huge plane proved its ability to launch the realistic Firebee targets for support of research, development, operational evaluation, and air crew training of the Air Force's Air Defense weapons systems.

The first two of the giant GC-130A's are expected to become operational early in 1960.

Under an Air Force contract of more than $500,000, Ryan has been participating in the project to modify two Hercules prop-jets at Lockheed's Marietta, Ga., division for the Air Force Research and Development Command, and to assist in the flight

(Continued on Page 31)

"Beams" from RYANAV unit in tail of Grumman Mohawk observation plane keep Army's aerial scouts advised as to precise position.

ELECTRONIC INDIAN GUIDE

Army awards Ryan $4 million contract to provide RYANAV* electronic guidance for Grumman AO-1 Mohawk

A CONTRACT for nearly $4 million, assuring production into the spring of 1960, has been awarded Ryan by the U. S. Army Signal Supply Agency for installation of the Model 120A Electronic Navigator in the Grumman YAO-1 Mohawk prop-jet observation plane.

This navigation set is a small, light-weight, all-weather, self-contained, integrated navigational and flight instrumentation system. The Model 120A employs continuous-wave Doppler radar to determine aircraft ground speed components. It computes and displays ground speed, drift angle, ground position, ground track, wind speed and direction, course and distance-to-destination,

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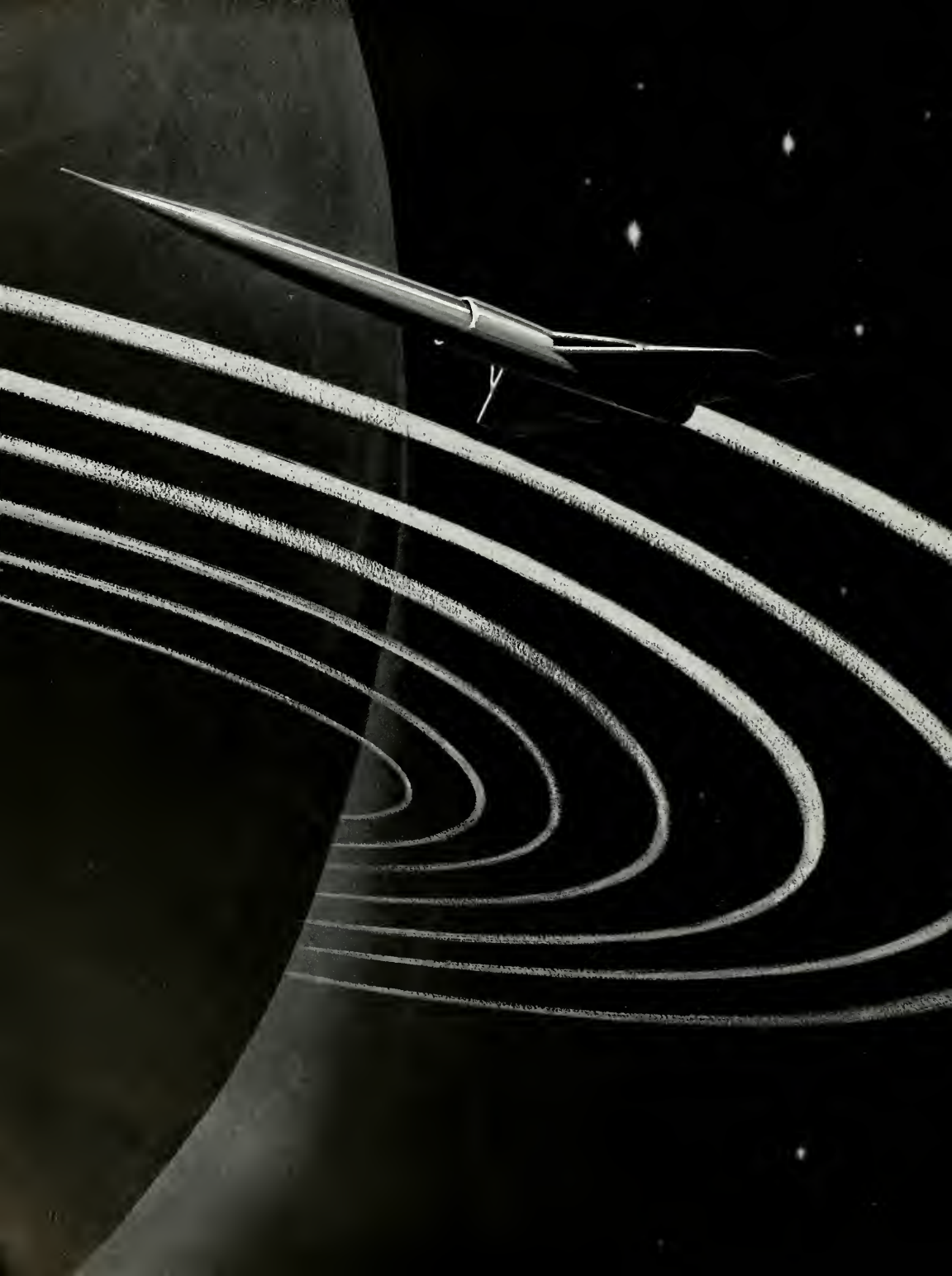
**Trademark*

RYANAV* antennas, held here by Ryan employee Merri Lee Carr, are light-weight, can transmit and receive simultaneously.



WINGS FOR THE ATOM

Ryan builds huge scrolls for nuclear aircraft engines

" . . . ne'er stoops to earth her wing, nor flies
Where idle warblers roam . . . "
The Bird Let Loose
Thomas Moore

A BIRD soon to be let loose, one whose wings will stoop to earth but infrequently, will be the nuclear-powered airplane. It will be able to stay aloft so long that there is discussion of changing crews in mid-air, rather than returning the plane to base.

While the airplane hasn't yet been built, the atom has shown that it can supply enough heat to power a jet engine. In Idaho, General Electric collected the heat from a reactor in specially designed Ryan-built scrolls, and pushed it through a converted J-47 jet engine.

The atom's ability to provide power has been thoroughly proved in the Navy's Nautilus and Skate. And, contrary to early opinion, these engines are far more docile and trouble-free than conventional steam turbines and diesels. It's been reported that the crew members aboard nuclear subs receive less radiation than does a person in the average city. There is little question that the ships of the future, commercial and naval, surface and submarine, will be equipped with atomic engines.

However, it's one thing to put a reactor and enough shielding to protect its operators into a structure weighing 3,000 tons, and quite another to put a reactor and shielding into an airplane weighing but 500,000 pounds. There are alternatives to the simple and direct method of surrounding the reactor completely, however.

To keep the weight and size of the atomic airplane down to a reasonable figure, say 200,000 pounds, the best alternative would be to shield the passengers and crew rather than the reactor. In fact, tests conducted by Convair, who installed a 1,000 kw. reactor in a B-36, indicated that reducing shielding weight can be effected by dividing it between the reactor and the flight crew's compartment.

While important, the solution to the problem of proper shielding must await the development of a power unit which would fit inside a 3-ft. diameter by 3-ft.-long cylinder, and which would develop about 30 megawatts of heat. AT 750°C, this output would produce the equivalent of 10,000 h.p.

General Electric, in its development program located at the National Reactor Testing Station, near Idaho Falls, Idaho, has made some important progress toward this goal. GE has run a modified J47 turbojet engine—designated the X-39 for this purpose — for more than 100 hours on nuclear power alone.

This nuclear power plant is the direct cycle type, in which the engine air passes through the reactor

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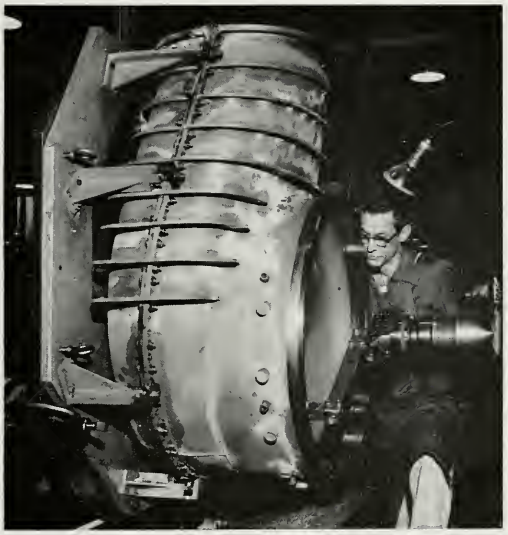
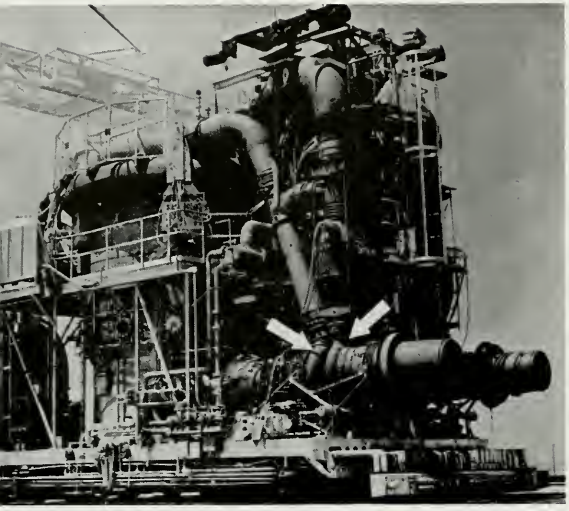


Atom-powered plane (opposite) could circle the earth at high speeds, high altitudes for long periods of time without refueling. Ryan-built scroll (above) for experimental nuclear engine was precision tooled to close tolerances. Here, Ryan's Leslie Loy finish-machines face flange with big boring mill.



Ryan-made scrolls (arrows), operate in General Electric nuclear test engine set-up. Atomic reactor and support equipment were deliberately made large for instrumentation, easy maintenance.

to cool the reactor as well as to provide thrust. Although in a final design the reactor would be in the same package as the turbojet, in the test set-up the reactor is apart from the engine. It is a massive unit, mounted on a railway flat car. Ease of access and maintenance, and installation of a great deal of testing and recording equipment dictated the size of the test bed.

In operation, air is drawn into the engine intake, compressed, collected in a special scroll mounted behind the engine compressor, and then routed through the reactor core. Heated by the nuclear process, the air then returns to a second scroll, is used to turn the turbine which drives the compressor, and is then exhausted through the jet nozzle to provide thrust.

In the test bed, the atom gets some help from conventional chemical fuels. In the ducting which returns from the reactor, GE engineers installed a combustion chamber. When the engine is first started, it's started on chemical fuel, and, as heat from the reactor builds up, the chemical fuel is shut down.

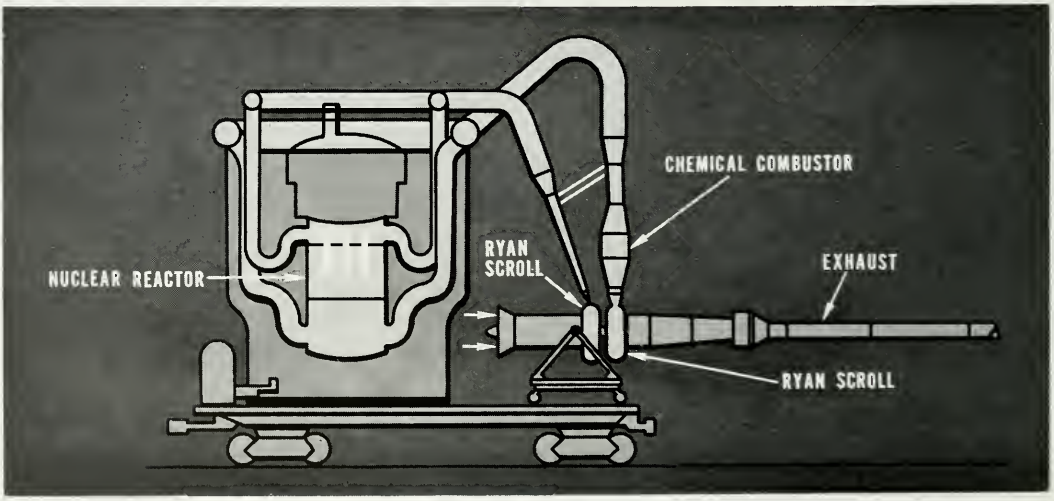
When the nuclear-powered plane becomes a reality, it's most probable that, like the turbojet engine, it will be used primarily for military purposes for some years to come. There are several types of military aircraft, flying various missions, that can profitably use atomic power.

Most obvious is the nuclear-powered seaplane. The big flying boats could cruise indefinitely on anti-submarine warfare patrol, as airborne early warning ships, and on long-range patrol and reconnaissance. They would be invaluable in weather, search and rescue missions, and their potential for high speed would make them highly suitable as a low-level attack bomber.

From the standpoint of commercial craft, the seaplane might also be the logical choice. An atomic-powered commercial transport would have to be of gigantic size, able

(Continued on page 35)

Cutaway of engine shows how air enters jet, runs through Ryan scroll into reactor, is heated and forced through exhaust for thrust.



DOUGLAS DELIVERS DC-8

United Air Lines accepts first of 40 Ryan-equipped DC-8 Jet Mainliners

RECENTLY, in Long Beach, California, Douglas Aircraft Company delivered to United Air Lines the first one of 40 DC-8 Jet Mainliners. The big plane is expected to go into scheduled service in September, about four months from the date of delivery. A major factor in keeping them on schedule will be the precision construction of the Ryan-built pods and pylons.

The first four of the forty planes will enter an extensive program of testing, training and familiarization which will occupy them night and day for nearly five months. Upon completion of the United program, they will undergo three additional months of tests, at the conclusion of which they will be formally certificated by the Federal Aviation Agency.

In the meantime, additional DC-8s, already certificated by the FAA, will be delivered to United, and placed in scheduled service in September.

Ryan's ability to turn out precision parts on schedule has played a large part in enabling Douglas to meet the tight delivery schedule set by United. To meet Douglas schedules, Ryan has installed the largest and most advanced equipment available for hot-forming titanium and has constructed one of the most modern factory buildings in the aviation industry for assembly-line production of the DC-8 pods and pylons.

Ryan will also directly assist United Air Lines in keeping the big DC-8 Mainliners flying. Ryan Field Service Representatives will be available to provide technical assistance in engine build-up, and in the techniques of quick engine change. Ryan is presently producing quick engine change kits for the DC-8, so that airlines can keep downtime at a minimum in the event of engine malfunction.

Douglas Vice Chairman F. W. Conant, and Chairman of the Board Donald W. Douglas, with Ryan President T. Claude Ryan, at delivery of first UAL DC-8.

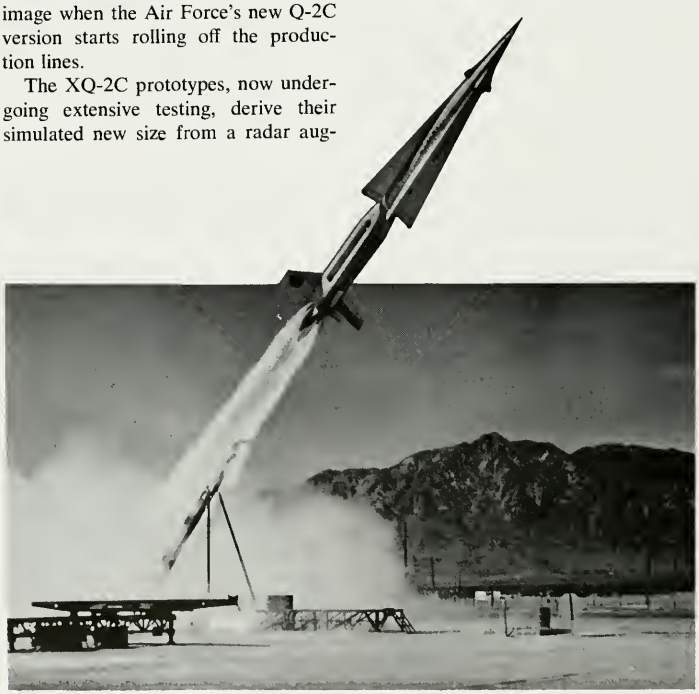
United Air Lines President William A. Patterson, and Ryan discuss the future of the Douglas DC-8 as they stand in front of Ryan-built pod and pylon.

THE BIG IMAGE

Ryan Firebees give bomber-sized radar image through Traveling Wave Tube radar augmentation

THE Tom Thumb-sized Ryan Firebee jet target missile, most widely used "enemy" of the nation's defense system, will assume a Paul Bunyan radar image when the Air Force's new Q-2C version starts rolling off the production lines.

The XQ-2C prototypes, now undergoing extensive testing, derive their simulated new size from a radar augmentation system utilizing a traveling-wave tube amplifier. The system, a series of electronic "black boxes," can be modified to evaluate air-to-air and ground-to-air missile systems now in the defense arsenal.



The traveling-wave tube (T-W-T) amplifier, housed internally in the Firebee, and connected by coaxial cable to the receiving and transmitting antennas on the missile's outer shell, can respond with boresight information. With this active augmentation system, the Firebee meets target requirements for the Falcon, GAR-1, -2, -3, -4, and -8, the Genie, Bomarc, Hawk, Talos, Nike Ajax and Nike Hercules weapons systems.

The traveling-wave tube can give the 22-foot long Firebee the average radar "echo" size of the Air Force's B-52, or the Russian "Bison" bomber.

Although the Ryan Firebee has long been a target for the nation's air defense teams, its passive area augmentation systems gave limited radar response from some angles and from long distances.

In 1957, the Air Force, foreseeing the reflectivity requirements of new missiles, asked for studies and possible

Various systems in the T-W-T "black box" hook-up fill radar response requirements for the Army Nike missile and other weapons in the nation's defense arsenal.

design changes to enhance the Firebee's radar response. Ryan engineers answered with the application of 13-inch diameter wing-tip pods to the Q-2A version of the Firebee.

The pods contained Luneberg lenses and corner reflectors to fill "X" and "C" band missile guidance system requirements and an IFF type beacon to provide accurate "L" and "S" band tracking information.

The response of the passive Luneberg lenses and corner reflectors provided only a monostatic response to the inquiring radar, by reflecting the radar beam with an appreciable amount of gain. Additionally, the physical size of the pods imposed aerodynamic penalties on the target.

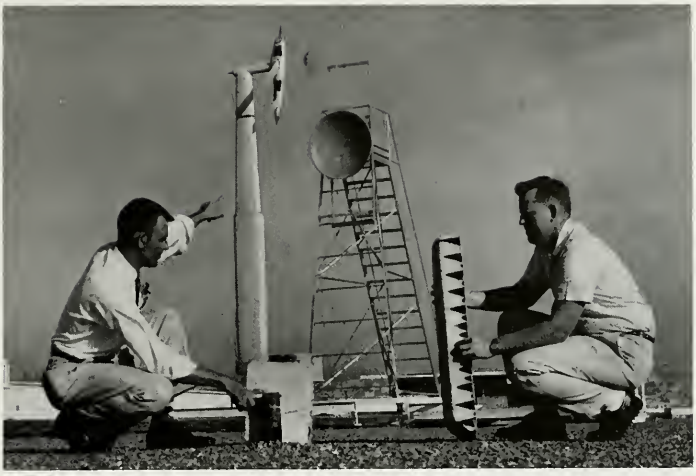
Although these passive devices were relatively inexpensive, with an adequate degree of reliability, their inability to provide the bi-static response required for semi-active homing systems made the study of newer and better reflectivity devices imperative. Ryan engineers decided the traveling-wave tube was the active device needed to provide a realistic target for the evaluation of the nation's defense system.

Basically, the traveling-wave tube is a broad-band, high-gain device with the ability to detect moderately low-level signals (approximately 50 decibels below a one milliwatt level) and amplify the signals, with minimum delay, an average of 30 decibels above the incoming level, while retaining the particular characteristics of the input signal such as frequency, pulse repetition rate, pulse width, and relative amplitude.

The Firebee application employs two traveling-wave tubes in cascade, supplying an average gain of 60 db and maximum power output of 1 watt.

The complete radar augmentation system consists of three basic components; the permanent magnet-focused tubes and the power supply (both in a black box), and the antenna system, located on the surface of the target.

ITT Laboratories, a Division of International Telephone and Telegraph



Antenna locations on the Firebee's outer shell are calibrated at Ryan's "rooftop" radar range. Ryan electronic engineers Bergholz and Middleton check radar angle.

Corporation, designed and developed the components of the system according to systems specifications originated by Ryan. In the design ITT Labs utilized traveling-wave tubes manufactured by Huggins Laboratories, Sylvania, and the Radio Corporation of America. Ryan engineers de-

(Continued on Page 32)

Larry Anderson peers at "box" through window of cold test cell. Laboratory environmental tests preceded the operational testing of the T-W-T equipment.

The compact T-W-T "black boxes" were flight tested by Ryan in an F-94 jet fighter, for ground and air radar response. Engineer Robert Emert installs "L"-band box in F-94.

PEG-BOARD PRODUCTION

"Room-service" technique saves time, space and money

REMEMBER the erector set of your childhood?

Its principles of using slotted perforated sheet metal angles to create various structures are being applied at Ryan to create new material handling and storage facilities. In conjunction with the "erector sets," perforated quarter-inch thick masonite pegboards are being used to create acres of storage space where bare walls had been.

The slotted angles were first used to make small tool racks. Later, portable A-frames, with pegboard sides, were used in the Douglas DC-8 pod and pylon program. The A-frames are padded with foam rubber to prevent scratching the pod and pylon parts, and special rubber-covered hooks hold the parts in position on the A-frame. Each part is placed in exact assembly sequence on the board, so that installation of the part is nearly fool-proof.

In other areas, complete walls have been covered with the pegboards, creating storage space without interference with activities on the floor. In some areas, due to the special shape and odd curves of some of the parts, storage shelves took up a considerable amount of floor space. With the pegboard in place, parts are hung on the wall, at hand when needed, and safe

Small parts roll to right spot on Ryan-devised cart. Ryan's John Wattendorf checks nose cowl as Insp. R. C. Eaton re-stocks supply.

from damage. Conventional shelving for these parts costs more, too. It has been estimated that one $6.80 sheet of pegboard will handle more parts than a commercial shelving unit costing $37.50.

Use of the wall-hung pegboards in assembly areas provides a "self-service supermarket" facility for assemblers. All parts for an assembly are on the boards, and the assembler helps himself as needed. The foreman can see at a glance which parts are available and which are in low supply.

The self-service method is also followed in areas where wall-hung boards aren't feasible. A-frames on wheels are filled with necessary parts. When one complete batch of parts is used up, the rack is pushed to stores for refilling. This has replaced a system of delivery by wheeled boxes at the request of the assemblers. A considerable amount of paper work and man-hours have been eliminated.

Closer control over the re-ordering of small parts—rivets, screws, washers, and the like—is another feature of the A-frame. Previously, these small parts were kept in open bins in central locations in various work areas. Now, they're put into small Mason jars and hung on the A-frames, which can be moved easily to the required work area. Each Mason jar is covered with tissue paper—held on by masking tape —whenever the jar is filled. If the paper seal remains unbroken for some length of time, it's obvious that re-ordering of that particular part is unnecessary.

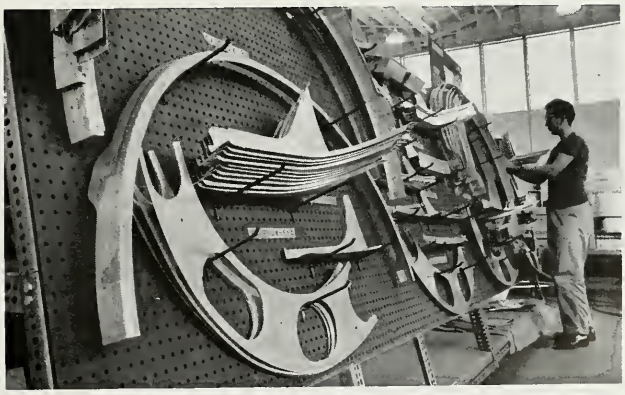
Ryan industrial engineers Jack Prince and Charles Jarvie started the new program to further improve a material handling method designed by Ryan some years ago. At that time, "tote" boxes, rectangular or square boxes on wheels, were used to transport various parts through the plant to work stations. Since many parts were of odd shape, efficient loading of the tote boxes depended almost entirely on the ingenuity of the employee, and, in many cases, some damage occurred to parts.

At that time, the solution to the

(Continued on Page 31)

Lots of material stored in small space are examined by Ryan Supervisor R. R. Boisvert. Quick glance at the board tells which parts are in short supply.

Bulky, hard-to-handle parts, like these ducts for the Douglas DC-8, here being examined by Ryan's H. D. Gerdes, are no problem when put on the boards.



Accuracy in assembly is assured with the A-frame and masonite set-up, since parts are put on boards in the sequence in which they are to be installed.

SHARP "EYES" FOR SKYHAWK

(Continued from Page 13)

continuously showing the heading he should follow and the miles remaining to the target. Position fixes obtained en route, if available, increase the navigational accuracy, and provide confirmation of the mission schedule.

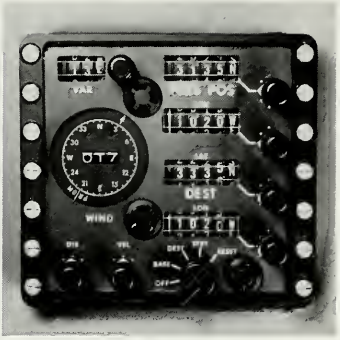
After the completion of his attack, the pilot moves the indicator switch on the navigational computer indicator to "base" position and the navigational data which had been stored enables him to return on a direct course to the carrier.

The AN/APN-122(V) is exceptionally compact, lightweight and rugged. It operates accurately under extreme flight conditions, yet can withstand the severe shock induced by catapult launching and arrested carrier landings.

Continuous-wave techniques, such as are used in the AN/APN-122(V) have been pioneered and developed by Ryan. By taking the fullest advantage of these techniques, the desirable combination of low weight, small size and simplicity has been achieved.

The AN/APN-122(V) features a unique, fixed-antenna system that has no moving parts, nothing to tune or adjust, and is sealed against dust and moisture, thus providing utmost reliability. The direct-to-audio Doppler detection system employed requires no I-F amplifiers or automatic control. An electrical analog data-stabilizing computer maintains precise signals even under extreme pitch and roll attitude of the aircraft. Wind computation and memory is automatic. The navigational computer is exceptionally small and light in weight.

Computations are performed using 400 cps a-c analog voltages corresponding to heading velocity and drift velocity. These outputs are combined for the computation of ground speed and drift angle, and are resolved using heading reference data from an external source to compute present latitude, present longitude, and ground track. Using set-in destination latitude and longitude, the system computes



Navigation computer gives clear continuous read-out of plane's present latitude and longitude, destination, wind velocity, direction, degree of compass variation.

course-to-destination and distance-to-destination. Wind speed and direction is computed and displayed by comparing true air speed and ground speed data, and is used for navigation during memory mode operation.

RYAN VERTIPLANE

(Continued from Page 11)

tion to four hours of flight testing.

The Office of Naval Research and the Army decided to renew the Vertiplane program on the basis of the need for flight evaluation of the deflected slipstream concept, and because of the success Ryan has experienced in the test program.

"The degree of success achieved by Ryan and other companies in the research and development of VTOL vehicles," Immenschuh said, "are strong arguments for the completion of the various test bed programs to furnish the Armed Services the best flight criteria for choice of an operational VTOL vehicle."

The repair program will incorporate some slight modifications to the aircraft to continue evaluation of the vertical take-off capabilities of the deflected slipstream principle.

Most significant change will be the redesign of the cockpit to accommodate a low level ejection seat. The cockpit, formerly enclosed in the fuselage, will become an open cockpit set in a tubular steel frame. In addition, a 12-inch section will be added to the fuselage forward of the wing section to move the pilot farther forward.

Modification plans call for lengthening and widening the main landing gear to improve the runway behavior of the craft. The change when completed will give the Vertiplane two ground line attitudes. For conventional runway take-off, the Vertiplane will utilize its tricycle landing gear, resting nose down before take-off. For hovering or vertical take-off, the Vertiplane will rest tail down before take-off. The tail down attitude positions the lift vector vertically when the slipstream is fully deflected.

Other minor changes will include the addition of a leading tab to the horizontal stabilizer, a center support to the wing flaps, and a booster pump for the fuel system of the gas turbine engine.

Nearly conventional in appearance and construction, the Vertiplane employs the deflected slipstream principle through two huge flaps which extend downward from the trailing edge of the wing. With the double retractable wing flaps extended, the deflected slipstream action is obtained from two large three-bladed pylon-mounted propellers, shaft driven by a 825 hp. Lycoming T-53 gas turbine housed in the fuselage. Power is transmitted to the props through a reduction gear box on the forward part of the engine and two transmitting connecting gear boxes aft of the propeller.

VTOL/STOL control is provided by wing spoilers for lateral control and by variable control devices in the tail for longitudinal and directional control. These controls deflect the exhaust from the engine.

The research contract for the Army Vertiplane followed extensive research by Ryan, the Air Branch of the Office of Naval Research, and the National Advisory Committee for Aeronautics, to advance slipstream research to the point of building an experimental aircraft. Previously, Ryan completed the first tests and studies of slipstream principles with full scale equipment for the Office of Naval Research.

FOUR AT A TIME

(Continued from Page 20)

test program, which will ultimately lead to air launching of four Firebees in timed sequence at Eglin Air Force Base, Fla.

The GC-130A can climb rapidly to 30,000 foot altitudes before releasing the one ton Firebee targets to fly under their own power by remote control, either from a ground director or from a director in the launch aircraft.

The GC-130A's, when fully developed, will carry their own microwave command guidance system, including tracking radars, command transmitters and instruments to record the Firebee's performance.

The GC-130A flies at speeds in excess of 350 miles per hour, and on its first flight took off in less than 2,500 feet even with a gross take-off weight of 100,000 pounds.

Complex electronic monitoring and control equipment for the target missile system will be in portable consoles which may be easily removed, permitting the plane to be used as a cargo carrier, assault transport, or flying ambulance.

The continuing flight test program from Marietta is under the direction of Al Donaldson, flight test engineer, with George E. Leonard, master mechanic, and P. J. Tamm and R. A. Sumpter, instrument technicians on the flight test crew.

NEW VICE PRESIDENT FOR TECHNICAL ADMINISTRATION

Edward G. Uhl, 41, recently joined Ryan to fill the newly created post of Vice President-Technical Administration, T. Claude Ryan, President, announced. He comes to the Ryan organization from his recent position as Vice President of The Martin Company and General Manager of its Missile Division at Orlando, Florida.

As Vice President-Technical Administration for Ryan, the functions of Engineering, Military Relations, Customer Relations and Public & Employee Relations will report to Uhl through their respective directors.

At Orlando, Uhl was in charge of an integrated Division operation. He also was responsible for construction of the new missile plant facility established by Martin at Orlando in 1957 for production of the Army Pershing and LaCrosse ground-launched and Navy Bullpup air-launched missiles as well as the Missile Master data-processing system.

Prior to his assignment to Orlando, Uhl was for four years Vice President and Chief Engineer of Martin at its Baltimore Maryland, headquarters where projects under his direction included the Matador pilotless bomber, P5M Marlin seaplane and P6M jet Seamaster, as well as the Viking research missile, predecessor of the Titan ICBM.

Credited by the Army as the co-inventor of the "bazooka' of World War II fame, Uhl was an honor graduate from Lehigh University, Pa., in 1940 with a degree in engineering physics.

Before joining Martin in 1946, Uhl served six years in the Ordnance Department of the Army, rising to rank of lieutenant colonel. Most of his Army career was in research and development in the office of the Chief of Ordnance, including work as project officer in the development of rockets and solid propellant fuels.

EDWARD G. UHL
New Ryan Executive

Beginning as a research engineer with Martin, Uhl rapidly advanced to Assistant Project Engineer on the Matador, Project Engineer on the Oriole guided missile, Head of the Pilotless Aircraft Section, Chief Project Engineer, and then Vice President and Chief Engineer responsible for all Martin engineering projects.

Uhl is married and has four children, ranging in age from 1 month to 15 years.

PEG-BOARD PRODUCTION

(Continued from Page 29)

problem consisted of welding together from pipe and shelving rolling racks specially designed to hold a given part. This worked fine, except that when a contract was fulfilled, the rack had little further use. To be re-used for parts of other shapes and sizes, the rack had to be cut apart, re-designed and re-welded together.

With the new method, once a cart or storage board completes its usefulness, it's a matter of minutes to disassemble the unit with wrenches, and store the component parts until they're required again. Salvage value is one hundred per cent.

FIREBEE GROUND LAUNCH

(Continued from Page 15)

Terriers—all have had their chance at the Firebee.

During the initial phase of the new Army project, Ryan will develop a rail launching system, and the zero-length system will be perfected during the second part of the program. In both systems, the target missile will be hurled into the sky with jet assist take-off (JATO) rockets. The Firebee's jet engine will then take over as the speedy target is directed on its mission by a ground remote controller.

In the first phase of the program, to be conducted at the Army's White Sands Missile range in New Mexico, XM21 Firebees—among the first target missiles built by Ryan—will be used with the rail launcher.

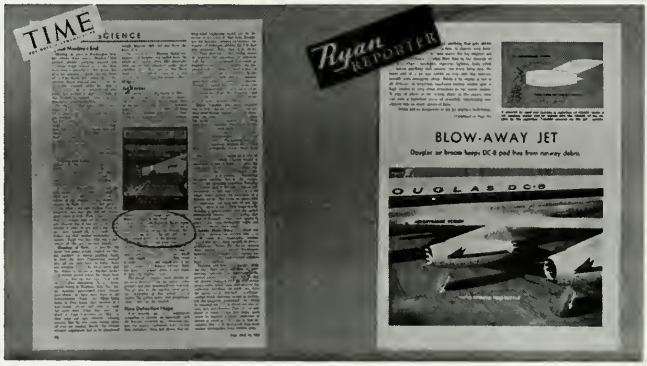
Later, an improved version of the Air Force's Q-2A, will be flown from the zero-length launcher. This model will carry five-foot wing pods equipped with radar augmentation devices.

Use of the ground-launching system will increase the versatility of the Firebee, since it supplements the present method of air launching from "mother" planes, utilized by the Army, Air Force, Navy, and Royal Canadian Air Force.

LIFE AND TIME FEATURE RYAN

Imagination—in engineering and in photography — paid handsome dividends for Ryan in recent issues of LIFE and TIME magazines. Ryan photographer Ted Lau's highly original treatment of the big exhaust ducts, made at Ryan for Douglas C-133 prop-jet transport planes, appeared in a steel industry story in LIFE magazine. Lau placed some of the Ryan employees who manufacture the stainless steel ducts, inside with the men's faces peering from holes near the top. To most people, the workers looked like men in individual rocket ships, although LIFE called them "a muster of humpty-dumpties."

TIME picked up a story, from a recent issue of the RYAN REPORTER, which discussed the success Douglas engineers had in combating a jet engine's inclination to suck debris up from the runway into the engine air intake. Designed by Douglas, the system is incorporated in the jet engine pods and pylons which Ryan builds for the new DC-8 Jetliner.



THE BIG IMAGE

(Continued from Page 27)

termined the packaging, installation, power and antenna requirements.

The traveling-wave tube, as developed initially, was a sensitive, high-gain, wide-band amplifier for laboratory use. The first tubes were large, with inadequate power output for radar augmentation, and in general were not rugged enough for airborne application. Later developments of the tube with its associated magnets had the necessary power and ruggedness for application to the Firebee system.

The traveling-wave tube is a vacuum tube with an electron gun, similar to the type used in the picture tubes of home television sets. However, instead of employing a sweeping electron stream from the electron gun as the television set does, the traveling-wave tube confines the electron flow to a narrow beam, making the tube envelope as small as possible.

Electrons emitted by the gun are drawn along the tube to a collector electrode at the other end. The tube is enclosed in a magnetic field keeping the electrons focused in a beam as they traverse the length of the tube.

Between the electron gun and the collector electrode, a wire helix, similar to a long coil spring, is mounted inside the tube envelope. The speed of the electrons down the center of the helix depends on the DC voltage of the collector and is normally 1/20 the speed of light. The two ends of the helix are coupled through coaxial leads or wave guides to the receiving antenna nearest the electron gun and to the transmitting antenna nearest the collector plate.

The diameter spacing of the helix regulates the transverse velocity of the wave motion of the received frequency (RF) energy to slightly less than the speed of the electrons, allowing the signal wave and the electrons to travel down the tube at almost the same speed.

Amplification of the signal starts at the beginning of the helix when the

(Continued on Next Page)

electrons in the beam rearrange themselves in bunches, according to the electromagnetic energy or polarity of the RF wave. Then, as the bunched electron stream passes the turns of the helix, it appears as on alternating current which induces a voltage into the helix by the electromotive principles of a generator. The induced voltage is in phase with the RF signal and strengthens it.

The resulting stronger RF wave then causes greater bunching of the electrons, and the process repeats continually down the tube gradually building amplitude.

The repeated transfer of energy to the helix causes the electrons to slow down, and amplification will continue until the electrons can no longer keep space with the wave. As this electronic foot race reaches the finish line, the amplified wave is coupled off the helix and the electrons are caught up by the collector electrode.

The gain of the traveling-wave tube can be increased by using a higher DC voltage on the collector electrode or by making the tube longer. Because of the repeated exponential amplification, the gain of the tube can be increased considerably with a relative small increase in its physical length. The length of the T-W-T is limited only by the ability of the focusing magnets to control the flow of the electron beam down the helix structure.

The speed of the wave down the wire helix is independent of frequency and thus the traveling-wave tube will amplify over a very wide frequency range.

The Firebee application of the tube employs permanent magnets to hold the electron stream in precise focus down the center of the helix. Twenty-eight volts of direct current are required as primary power.

Arrangement of the receiving and transmitting antennas on the Firebee's outer shell proved to be the biggest problem facing the Ryan and ITT Laboratory engineers. The antennas had to be located for satisfactory pick-up and transmission of the RF signal. Elevation and azimuth coverage as well as isolation between receiving and transmitting antennas of a given system were determining factors.

To solve the problem, the engineers performed exhaustive tests on a one-quarter scale Fiberglas model of the missile at ITT Laboratory's antenna range. Substantial tests of individual antenna designs were performed at Ryan's new radar antenna range. Response of antennas placed on the Firebee was recorded from every angle, as the missile, mounted on a special tower, turned along its azimuth and elevation axes during the testing. Analysis of the tests formed the basis for the final array of multiple antennas on the Firebee's surface. The antenna viewing angles range from 90 degrees in azimuth and 130 degrees in elevation to 360 degrees in azimuth and 90 degrees in elevation.

The antennas can be connected through coaxial leads to the traveling-wave tube packages carried internally in the Firebee.

The XQ-2C has a capability to carry three of the four "X," "C," "L," or "S" band frequencies on any given mission.

The traveling-wave tube augmentation systems are now undergoing extensive flight tests in an Air Force F-94 jet plane flying from the Ryan plant in San Diego. In the ground-to-air phase the F-94 flies a test pattern off the coast of San Diego, while the radar units at the Fleet Air Defense Training Unit on Point Loma evaluate the response of the amplifier in the F-94.

In the air-to-air phase of the flight test program, the F-94 assumes the role of target for a heavily instrumened C-131 aircraft provided by Hughes Aircraft Co., and an instrumented F3H aircraft from the Naval Missile Test Center, Point Mugu, California. Results of the flight tests against both ground based and airborne radars have proved that the amplifier will exceed the specification requirements.

Future tests of the new augmentation gear will be flown in the XQ-2C at Holloman Air Force Base near Alamogordo, New Mexico, where Ryan test teams maintain a test and improvement program on all models of the Firebee.

In recent flight testing the XQ-2C has reached an altitude of over 59,000 feet, a record for turbojet targets and has sustained a record flight of 96 minutes duration, after launching.

Parts Conferences Completed

Important conference of Ryan officials with representatives of Navy agencies and bases has been conducted to determine spare parts required for operation of Ryanav AN/APN-122 (V) automatic navigator devices in the Electronics Division's $20 million contract. R. F. Chadwick, Ryan project engineer, at left, welcomes Navy men, left to right, Frank Hoff, Naval Avionics Facility, Indianapolis; John N. Akarman, Aviation Supply Office, Philadelphia; Frank Oglesby, N.A.F.; James F. Kelly, A.S.O.; K. H. Maxwell, A.S.O.; James W. Schaffer, A.S.O., provisioning team chairman; E. L. Smith, A.S.O.; Morris Davis, A.S.O.; Manning A. Merriken, Paul Harshberger, Carl Masters, and Franklin Baker, all of North Island; and E. Bruce Link, Naval Aviation Engineering Service Unit, Commander Naval Air, Pacific.

ELECTRONIC INDIAN GUIDE

(Continued from Page 21)

aircraft altitude and heading. The system operates automatically, continuously and accurately without the aid of ground stations or wind estimates.

The Mohawk is a two-place plane, which features a 55-knot stall speed, is designed to operate from small unimproved fields, and has relatively the same short take-off and landing capabilities as the Army's present lightweight, single engine airplanes. It is, however, one of the largest (7700 pounds empty) fixed-wing aircraft ever to enter Army service. It is powered by two Lycoming prop-jet engines (rated at 1005 ESHP each), has a wing span of 42 feet and an overall length of 41 feet. It is the first Army airplane to utilize prop-jet engines and the first Grumman airplane to join the Army ranks.

Operational versatility is enhanced by skis which enable the Mohawk to operate from mud, sand or snow. The skis bear the load of the airplane and the tires protrude through the bottom permitting a certain amount of wheel braking.

The basic outputs of the Model 120A are aircraft ground speed in the heading and drift directions which are appropriately combined for the computation of ground speed and drift angle. By the use of heading reference data, the system computes present latitude and longitude. True air speed data is not required, except for the computation of wind information. The latitude and longitude of a destination are set-in manually and the system computes course - to - destination and distance-to-destination from the present aircraft position. It will also compute the course and distance from the present position to the base.

During periods of desired radar silence or Doppler loss, the system operates in its memory mode on the basis of remembered wind and true air speed. By virtue of its narrow beams and narrow band width, the Model 120A is adequately secure from enemy detection and counter measures.

An outgrowth of Ryan's 12-year program of research and development in continuous-wave radar, the Model 120A is the latest of several electronic navigational systems which Ryan has produced for the U. S. Army. It was preceded by the Model 103 in October, 1956 and the Model 108, which was delivered to the Army in February, 1958.

The Models 103 and 108 were successfully flight tested in Army aircraft at the Army Electronic Proving Grounds, Fort Huachuca, Arizona. The success of these programs led to the present Model 120A, which is being readied for installation in the Grumman Mohawk.

Major components of the Model 120A include a receiver-transmitter, power supply, amplifier assembly, signal data converter, ground speed computer, ground speed and drift angle indicator, bearing and distance indicator, control indicator, vertical reference system and heading reference.

The receiver - transmitter radiates two narrow beams of continuous-wave energy downward and outward. They can be directed ahead of or behind the plane's line of flight. A portion of the energy which reaches the earth is reflected back to the antenna. Because the aircraft has components of velocity along these radar beams, the returned energy experiences an apparent shift in frequency which is directly proportional to the beam components of the plane's velocity. This frequency change is called the "Doppler effect."

The detected signals from the receiver-transmitter are fed to the signal data converter which automatically searches for, acquires and tracks the signals to provide analog outputs proportional to the Doppler frequencies. For level flight, the *sum* of these frequencies is proportional to the aircraft speed over the ground. The *difference* between the frequencies is proportional to the speed in the drift direction.

The ground speed computer stabilizes the Doppler signal data for aircraft pitch, roll and vertical speed. The outputs of this unit provide heading and drift speeds, and are orthogonal components of the aircraft ground velocity.

With continuous-wave radar it is necessary to separate the transmission and reception which occur simultaneously.

The proved method of separation is achieved by "space duplexing" whereby transmission and reception employ different antennas. By ingenious design, Ryan engineers have achieved space duplexing in a single receiver-transmitter assembly. The radar reflector is divided into two parts by a septum which contains the microwave circuitry.

Doppler signals are detected by a direct-to-audio technique. Energy reflected from the earth along each beam is received and introduced into crystal mixers. A small portion of the transmitted energy is continuously and directly compared with the received energy to provide direct detection of the Doppler frequency shifts resulting from aircraft motion. There are no I-F amplifiers, local oscillators or automatic frequency control in the Model 120A. The result is the simplest, most reliable method of signal detection.

The antenna system on the Model 120 is rigidly fixed to the aircraft and data stabilization is used. The result is high reliability, low installed weight, small aircraft cut-out area, low volume, low power consumption, ease of calibration and greater attitude coverage.

OPERATIONAL CHARACTERISTICS

Ground Speed	50 to 300 knots
Drift Angle	0 to ± 45°
Maximum Vertical Speed	3,000 feet per minute
Altitude	0 to 25,000 feet
Attitude	± 80° pitch and roll
Accuracy	1.0% RMS or Ground Speed .5 RMS in Drift Angle

PHYSICAL CHARACTERISTICS

Type of System	C-W Doppler; two fixed radar beams, data stabilization
Approximate Weight (including mounts)	130 pounds
Approximate Volume	3.2 sq. ft.
Approximate Radome Aperature	2.0 sq. ft.
Antenna Beamwidth (two-way)	4° TWB
Approximate Transmitter Power	1 Watt
Transmitter Frequency	13,300 mc/s

WINGS FOR THE ATOM

(Continued from Page 24)

to carry hundreds of persons single flights of 5,000 mile range, in order to justify the initial cost of construction. And, since there's so much water available as runway space, perhaps we will again see the day when the seaplane rules the passenger trade on the intercontinental runs, as it did in the nineteen thirties.

The atomic engine isn't limited to the pure jet. Atomic energy can also be used to power propjets, either by bleed air from the reactor, or by installing a reactor in line with the engine, as with the turbojet. Such propulsion units would be used in very large logistic transports, which could deliver vital material or personnel to any place in the world, and return to the United States without refueling.

Ryan is again playing the pioneer's role in this newest phase of the story of aviation, just as it has for thirty-five years. Ryan built the scrolls which were used in the GE test engine in Idaho. Nearly five feet high, and more than four feet wide, these units tested Ryan's working skill to a high degree.

The units are made of stainless steel, Inconel, and L-605 alloy. Tolerances, for the most part, had to be held to within five one-thousands of an inch. These tolerances were not only called for in machining flange faces, but in maintaining overall dimensions. Special tools and techniques had to be employed, and, in order to machine the flange faces, a tool was imported from Germany, for use on a big horizontal boring mill.

Typical of the care which was called for was the construction and placement of the rib assemblies which surround the opening in the scroll. About five inches long, these 16 ribs had to be clamped to the cone assembly in equally spaced positions, and then led through openings in the outer cone. Spacing between ribs, and the length of the ribs, had to be held within five one-thousands of an inch. In addition, the opening through which the ribs passed had a clearance of only five one-thousands.

This close-tolerance, high-precision metal work is a Ryan hallmark. And Ryan-built parts will fly in the nuclear-engined airplanes of the near future, just as they do in today's global B-52 bombers, their companion KC-135 tanker-transports and the great DC-8 intercontinental Jetliners.

RESEARCH VEHICLE

(Continued from Page 14)

search project aimed at meeting the terrific stress, temperature and weight limitations imposed by hypersonic flight speeds.

For several years, Ryan has been studying the MiniWate design in conjunction with the exotic metals—tantalum, molybdenum, titanium, and columbium—in an effort to combine the very high heat resistance of these metals with the structural rigidity of MiniWate.

PUSHBUTTON TARGET

(Continued from Page 7)

"In fact," White continued, "the Q-2C will outclimb an afterburning chase plane because of its remarkably steep angle of climb." The target's ability to perform climbing turns will allow it to spiral to the top of its flight envelope from a single command — 15,000 to 50,000 feet in 7 minutes.

Maintenance highlights of the refined target are many. A one-piece corrugated reinforced water-tight aluminum door allows access to the target's electronics compartment. Mounted on a piano-type hinge, with three quick disconnect fasteners, the door can be quickly opened for immediate access to the electronic components. Component layout in the compartment has been designed for simplicity and rapid

(Continued on Page 36)

World Tour For Vertijet

Farewells were given to one of Ryan's most famous planes, the X-13 Vertijet, when the spectacular VTOL (vertical take-off and landing) aircraft was displayed at the Ryan plant. The X-13, world's first pure jet VTOL to fly the full cycle from vertical to horizontal and back to vertical phase, was shipped to Norton Air Force base, San Bernardino, from where it will begin a world-wide tour to display it at various public events.

Electronics Division Visitors

High-ranking naval aviation officers view Electronics Division's vital work in the Doppler navigation field. Rear Adm. C. B. H. Hall, Commander, Naval Air Bases, 11th and 12th Naval Districts, in center; and Capt. Robert Jones, Director Fleet Air, San Diego, at left, are shown AN/APN-122 (V) automatic navigator equipment and AN/APN-97 helicopter velocity sensor by Eddie R. Sanders, right, Ryan executive advisor to Electronics Division's Director of Engineering and Customer Relations. Adm. Hall and Capt. Jones are among many officers and civilian engineers, holding posts in the San Diego and Los Angeles areas, who have recently visited the Kearny Mesa facility.

PUSHBUTTON TARGET

(Continued from Page 35)

maintenance.

Each component is mounted on an individual pull-out rack. "The design has cut maintenance time in the electrical compartment to a minimum," Reasoner said. "Repairs that took an hour-and-a-half in other target systems, now can be performed in minutes.

"An added feature,' he continued, "is the reduced ground check-out time, made possible by the automatic check-out capabilities of each electronic component. Additionally, a malfunctioning component can be replaced, plugged in and checked out without running down through the entire check-out procedure.'

The Q-2C is approximately five feet longer than its predecessors, the Q-2A and KDA-4. The added length houses internally all the equipment formerly carried in wing-tip pods. The streamlined Fiberglas nose cone houses refined electronics scoring equipment, while Luneberg lenses and other passive radar augmentation devices used on the Q-2A target have been replaced by a traveling wave tube radar augmentation system housed in the electronics compartment. The new augmenting devices give the 22 by 6 by 12 foot Firebee the radar image of a B-52. The system, made up of "black boxes" provides radar response on varied frequencies through receiving and transmitting antennas on the target's surface.

Other physical highlights of the new Q-2C include a refinement of the leading edge air foil to facilitate high altitude operation, and the addition of a ventral fin aft, for increased lateral stability.

The target's Continental J-69-T-29 jet engine gives the Q-2C 70% more thrust than the Q-2A Firebee and adds better high altitude operating characteristics.

A new light-weight, taped seam, two-stage parachute, developed by Ryan engineers, with the main chute measuring 81.6 feet in diameter, supports the Q-2C's added weight on recovery.

Extensive preliminary tests of the target's design and systems design were completed at Ryan's San Diego plant before the target was shipped to Holloman Air Force Base for flight testing. "Flight simulator and human engineering experiments gave us the necessary data to nail down the bugs in our design," Bill White said.

The Q-2C tried its "water wings" in San Diego bay during drop tests designed to test the flotation capabilities of the target missiles. Results showed the Firebee would float even with a full fuel load aboard.

The traveling wave tube application to the target was perfected at Ryan's "rooftop radar range" where antenna design and radiation patterns on the target's fuselage and empennage surfaces were studied. Flight testing of the system was conducted by Ryan engineers, using an F-94 jet interceptor, bailed to Ryan from the Air Force.

The first prototype models of the Q-2C were built at Ryan in San Diego and shipped to Holloman Air Force Base with new ground equipment. The production Q-2C's will be produced at Ryan's Torrance plant.

Flight tests of the new target system are under the direction of Ed Sly, Ryan Supervisor of missile flight test. Launches are made from a modified B-26 bomber bailed to Ryan from the Air Force, with a Ryan flight crew manning the aircraft and performing all launch functions. The flight crew is supported by a 40-man Ryan maintenance and ground crew.

The Q-2C, now in phase one of the flight test, will be gradually integrated into the Air Force flight test program. In category two of the program, the Air Force will gradually assume the responsibility of testing the target, and by phase three, the Air Force will take over full responsibility, completing the test program and declaring the Q-2C an operational target missile.

ANTI-SUBMARINE DOPPLER

(Continued from Page 2)

field by the steel hull of the sub. The lines of the earth's magnetic field, however, haven't all been charted, and some of the anomalies that exist react just like a sub.

However, the sub doesn't have every thing in its favor. Subs are operated by humans, who list, among other failings, curiosity. Curiosity can be as fatal to a sub as it is to the fabled cat. When a sub surfaces to peek, he is just as liable to be peeked at. When he's seen, it's pretty definite that he isn't a whale, or a school of fish, he's a sub, and homing torpedoes, depth charges, or atomic bombs can remove him.

To ferret out the sub, and destroy him, the United States Navy operates a complex array of anti-submarine warfare equipment, ranging from supersonic, long-range high-in-the-sky bombers to anti-submarine submarines deep in the sea. Included in the armada are aircraft carriers, sub-tracking planes, helicopters, blimps, destroyers, and long-range patrol bombers and early warning aircraft.

The best way to cure a blight is to stop it before it starts. So the Navy, with its supersonic bombers operating off the decks of the big fast carriers of the Forrestal class, and with its guided missile submarines, can attack the enemy on his home grounds, obliterating the subs in the building yards and submarine pens before they can get to sea.

Those subs prowling the shipping lanes will be hunted down and eliminated by the Hunter-Killer Groups. With an aircraft carrier as a nucleus, this HUK force includes blimps, helicopters, tracking aircraft, and destroyers. It also operates in combination with ASW submarines and land-based long-range patrol and early warning planes.

Note that aviation plays a big part in this most deadly game of pinning the depth bomb on the donkey. Its the blimps, the 'copters, the trackers, and the patrol planes who must find our elusive friends. They need, much more than does the destroyer, pin-point navigation devices, smoothly running, dependable engines, and sturdy airframes. Right here Ryan joins the anti-submarine warfare team. Ryan contributes brains (navigation devices), muscles (jet and piston engine hot parts), and frame (airframe components).

Typical of Ryan "brains" are the APN-122(V) navigation sets; the APN-97 systems; and the APN-125 sets. The APN-122(V) will be standard equipment in ASW seaplanes, ASW hunter-killer planes, and in attack and special purpose aircraft. The APN-122(V) automatically and continuously computes and displays ground speed and drift angle, and can put a pilot within ten miles of intended position on a trans-Atlantic flight.

The APN-97 can put a sonar-dipping helicopter over a precise spot in zero/zero visibility, and can be tied in with automatic stabilization systems to permit smooth, safe automatic transition from cruise speed to hovering condition. Like the APN-122(V), it also automatically and continuously displays the heading speed and the drift speed of the 'copter, and in addition, gives vertical speed.

The APN-125 is presently in the Navy ZPG-2 and ZPG-2W blimps to provide all-weather automatic navigation and hovering facilities. All in all, nearly every flying weapon in the Navy's ASW arsenal has a RYANAV* C-W Doppler "brain."

The RYANAV systems are backed up by Ryan "muscle" — hot parts for piston and jet engines. Through the years, Ryan has produced piston engine exhaust systems for nearly every airplane in the Navy's hangars, and for blimps and 'copters, too. For jet engines, the company has turned out afterburners — Ryan built the first afterburner developed by a commercial firm in the United States — and has turned out turbine casings, compressor rings, and other jet engine parts.

Ryan will continue to be part of the ASW team for some time to come. Advances in C-W Doppler navigation — already considered the most complete, lightest in weight, and most reliable of all radar navigation systems — will be built into the Navy's search system. More powerful jet engines, which will incorporate the new alloys, will have parts made by Ryan, which continues to develop new techniques for handling these tough metals. And, in the event that the Navy turns to atomic-powered seaplanes for search and patrol, Ryan experience in making parts for the experimental versions of the engine will contribute to the fulfillment of one of the Navy's most difficult tasks — the detection, classification, and destruction of enemy submarines.

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ON THE COVER

Looking like space-men with individual rocket ships, these are actually Ryan employees shielded behind the stainless steel exhaust ducts Ryan makes for the Douglas C-133.

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DOUGLAS DC-8 JETLINERS FLY WITH RYAN JET ENGINE PODS AND PYLONS

To build the jet pods and pylons for each Douglas DC-8, Ryan fabricates 14,000 parts—almost half of them from tough titanium.

Quickly demountable, each pod is a precision-made power unit—capable of operating on its own—interchangeable between Jetliners.

Ryan was selected to build these major DC-8 assemblies because Ryan is skilled in the engineering and production of high quality aircraft structures. This is the same quality of workmanship which has built a world-wide reputation for Douglas aircraft.

RYAN BUILDS ATOMIC ENGINE PARTS FOR G.E.

Ryan is building huge aircraft atomic engine components for the Nuclear Propulsion Department of General Electric Co. Details cannot be disclosed but it can be said that the components must be built with extreme precision and designed for very high temperatures.

Ryan has been handling such exacting projects for twenty years. That's why Ryan today has the skill, facilities, and experience to build single parts or complete systems for atomic, turbojet, rocket, or ramjet propulsion.

RYAN RADAR HELPS NAVY HELICOPTERS FIND SUBS

Now Navy anti-submarine helicopters can hover motionless under all weather conditions, while they probe the sea to put the finger on enemy undersea boats.

With Ryan's continuous wave Doppler radar systems (AN/APN-97), now being installed in the Navy's Sikorsky ASW Helicopters, pilots can hover, automatically, without relying on visual ground reference. This was previously impossible.

Hovering is essential to anti-submarine missions so that sonar detectors can lie motionless while they are dipped under the sea. Based on Ryan's leadership in CW radar applications, this unique new equipment is the lightest, simplest, most compact, and most reliable of its type.

Ryan REPORTER

VOL. 20, NO. 4

Full-of-flight Firebees are readied for shipment by Ass't. Foreman Ross Murray (center), Assemblers B. O. Coulombe (left), Neil Schmidt.

FIREBEE HIVE

Ryan's busy, bustling production lines have turned out more than twelve hundred free-flying jet-fast target missiles

THE Ryan Firebee is the nation's most successful, most economical, and most durable free-flying turbojet target. Firebees have flown more than 2100 missions, have flown after having fuselage and engine shattered by shrapnel from attacking missiles, and one has floated in salt water for ten days. At least one Firebee was flown twenty times, another was flown six times in seven successive days, and scores of them have flown five or more missions.

Behind these remarkable records lie sound design, highly skilled workmanship, and modern construction techniques.

Because the Firebee must withstand not only the smashing impact of intercepting missiles — which can do considerable damage even when armed with dummy warheads—but also has to take the jar of parachute landings on land and in the sea, its design emphasizes ruggedness. Yet, because the Firebee also has to be easily maintained, a relatively simple form of construction and assembly has to be followed.

The Firebee is made of aluminum, magnesium, and stainless steel in five major assemblies — fuselage, nacelle, wing, empennage and parachute containers (tail cone). These major units can be assembled into a fast-flying target by two or three men in little more than an hour, with a minimum of handling equipment.

The fuselage is of semi-monocoque construction with formed magnesium and stainless steel skins, dural longerons and dural and magnesium frames. The engine nacelle fits onto the forward lower section of the fuselage.

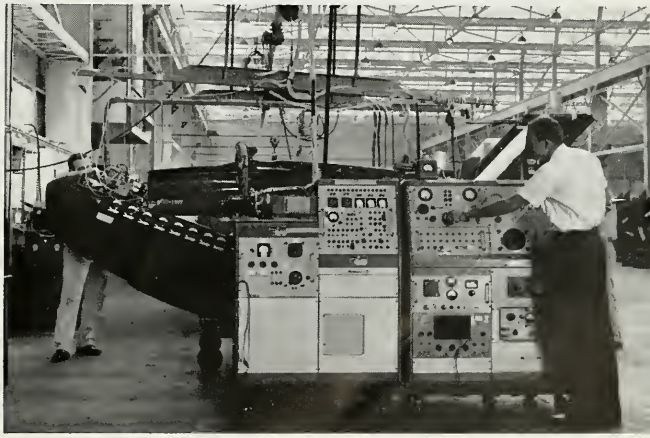
The nacelle is also of semi-monocoque construction with formed magnesium skins, on dural longerons and frames, and is attached to the fuselage at four points with the two forward fittings acting as hinges to permit easy access to the engine without removing the nacelle from the fuselage.

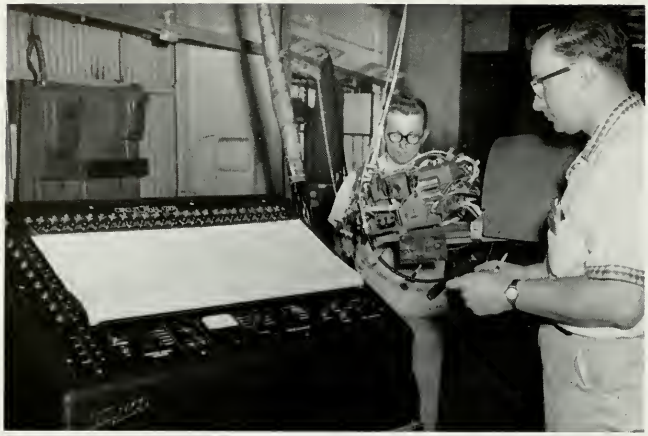
The wing is of full cantilever design. It's unusual in that no ribs are provided in the wing panels other than at the

(Continued on Page 2)

Power plant—a Continental J-69, rated at 1,000 pounds of thrust—that gives the Firebee its near-supersonic speed, is readied by Ryan's B. B. Welch for check and run-up in the Ryan jet engine test cell at Torrance.

Quick, thorough check of Firebee systems and components—including electrical, autopilot, and fuel — are made with this Ryan-developed console, operated here by Ass't. Foreman R. L. Burns and J. W. Drennan.





Bird's "nervous system"—the hundreds of feet of wiring harnesses that carry signals to its operating components, gets instantaneous complete check-out with the use of a circuit analyzer, operated by Jerry Drennan (left), and Kermit Colby.

Ailerons, elevators and rudder are of semi-monocoque construction with magnesium skin on light dural spars and are statically balanced.

Typical of the forward-looking design built into the Firebee is the extensive use of magnesium. Magnesium, weighing less than two-thirds as much as aluminum, and only one-fourth as much as steel, can be fabricated into heavier gauge structures without using stringers, angles, and other devices for stiffening.

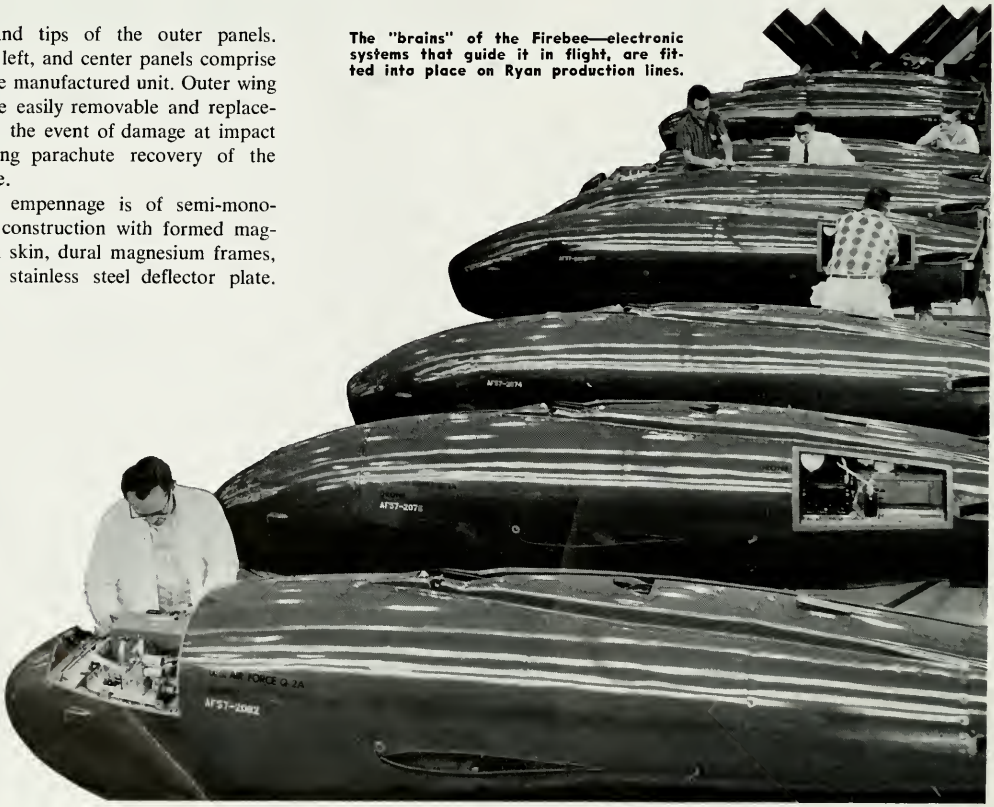
However, when the Firebee first went into production several years ago, techniques for forming magnesium sheet into complex-curved structures were in early stages of development. To build the Firebee of magnesium,

(Continued on page 25)

root and tips of the outer panels. Right, left, and center panels comprise a single manufactured unit. Outer wing tips are easily removable and replaceable in the event of damage at impact following parachute recovery of the Firebee.

The empennage is of semi-monocoque construction with formed magnesium skin, dural magnesium frames, and a stainless steel deflector plate.

The "brains" of the Firebee—electronic systems that guide it in flight, are fitted into place on Ryan production lines.



GEARED FOR GUIDANCE

Demand for Ryanav* electronic guidance and navigation systems fulfilled by skilled personnel, modern equipment, new facilities

ALTHOUGH a youngster in terms of the Ryan Aeronautical Company's long history of achievement, the Electronics Division has, nevertheless, carved an impressive niche in both the aeronautical and aerospace fields with numerous contributions to doppler automatic navigation and to missile guidance. The Division has achieved world-wide recognition.

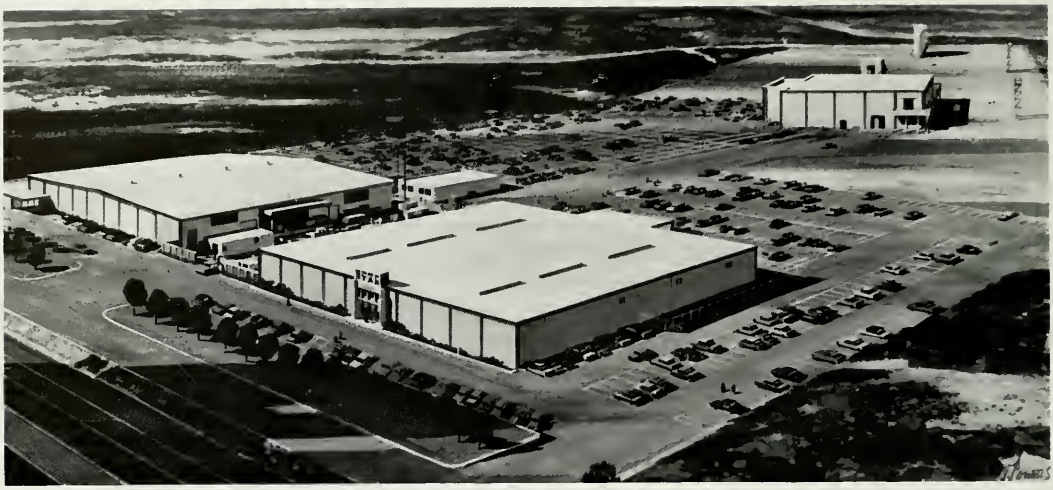
The Ryan Electronics' management team, headed by G. W. Rutherford, Division Manager, is experienced and energetic, and the pride and enthusiasm that runs high throughout the entire organization is well justified in light of the division's impressive backlog in business.

Ryan has been actively engaged in avionics for many years during which time an electronics engineering group headed by Owen S. Olds

(Continued on Next Page)

*Trademark

Microwave development boresighting tower, reoring forty feet into the air, helps assure the pin-point accuracy of Ryanav systems.



Talent teams with experience to create the nation's most advanced electronic guidance systems at Ryan's Kearny Mesa R & D center.

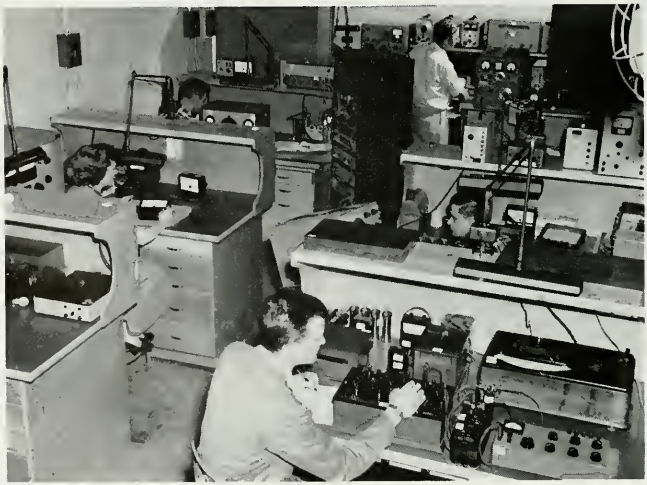
researched, developed and produced an impressive array of electronic devices for the government's aircraft and missile programs. This group developed the first successful C-W doppler navigators, devices acclaimed to be the most advanced and revolutionary *proved* means of aerial navigation yet devised by man.

The demand for Ryan doppler navigators grew rapidly as the military became increasingly aware of its capabilities and it was soon apparent that increased engineering and manufacturing facilities were urgently needed. In 1957 Ryan Electronics was established as a separate operating division.

Increasing acceptance of Ryan C-W doppler equipment by military services has greatly accelerated the growth of the division and today it represents an impressive assemblage of the nation's top engineering, manufacturing, financial, and administrative talent.

Daily, Ryan automatic navigators are finding broader applications in all types of aircraft, ranging from helicop-

Standards Laboratory, fully equipped and expertly staffed, sees to it that Ryan electronic navigation equipment does the precision job it was designed to do.



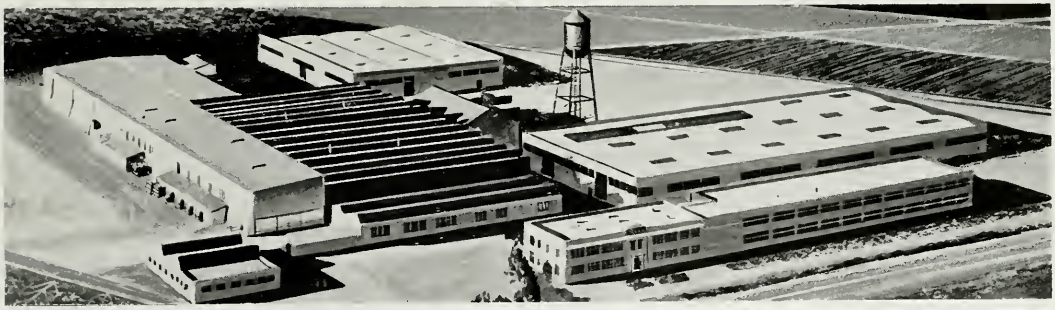
Artist in electronics. Sam Dell'acqua prepares to photograph circuit prior to etching.

ters and slow flying reconnaissance aircraft to high altitude supersonic jets. Looking to the future, new and more advanced Ryan navigators are being readied for missile and space navigation.

The physical facilities of this growing organization are impressive too. They comprise major plants on Kearny Mesa in San Diego and in Torrance, California. Totaling nearly 400,000 square feet of working area, these plants represent one of the most advanced and finest equipped electronics development and manufacturing facilities in the country.

The Kearny Mesa plant has two buildings at present; and a third 28,200

Accuracy in automatic navigation demands systems built to exact standards by highly skilled personnel, like these workers at Ryan's production stations.



From research and development at Kearny Mesa, guidance systems move into production at Ryan's 40-acre plant in Torrance, Calif.

square foot two-story structure, which will house the engineering and environmental laboratory, is scheduled for occupancy during October, 1959.

Kearny Mesa is the division's engineering and customer relations headquarters. It comprises the program management offices, research and development, field engineering, advance design, engineering services, reliability, and the customer relations organization. Also situated on this 20-acre site are the facilities' support groups, which include administrative functions, procurement, security, industrial engineer-

(Continued on Page 28)

"Black box" for a Ryanav automatic navigation system begins to take shape under Ryanite's careful hands, watchful eyes.

Major Van Walker, skipper of the 4756th Drone Squadron, will be "enemy" commander again at "William Tell II".

WILLIAM TELL I: RECORD BREAKER

First Weapons Meet to use Ryan Firebees set ten "firsts" last year

THE TOWED target is obsolete. It became obsolete on October 20, 1958—opening day of Project "William Tell II", when a free-flying, jet-fast target missile—the Ryan Firebee — flashed across Tyndall Air Force Base in Florida, to challenge the skill of the Air Defense Command's finest pilots, and the strength and effectiveness of their weapons.

The ADC's men and weapons met the challenge. From Detection, through Identification, to Interception and Destruction, the interceptors and their Ground Controllers functioned with amazing smoothness and uncanny accuracy.

More than records for accuracy and combat readiness were set during this historic meet. For the first time—

Free-flying jet targets—Ryan Firebees—were used in a weapons meet. Pilots fired real rockets and missiles against fast-moving aircraft, rather than slow towed targets, to get a true evaluation of air defense capability.

For the first time the Ground Controller-Pilot teams

(Continued on Page 26)

Badly battered in a split-second battle with a supersonic missile, Firebee target is examined by 4756th personnel after its return. 22 Firebees suffered similar fate at William Tell I.

RYAN FIREBEE AT PROJECT "WILLIAM TELL II"

USAF Vice Chief of Staff General Curtis LeMay said this: "Survival may depend upon the skills of the men who man the weapons of the Air Defense Command. Project William Tell is the most realistic proving ground, short of actual combat conditions, that we can provide to evaluate these vital capabilities."

Once again, at "William Tell II," the Ryan Firebee will provide the best means available to test the men and aircraft of America's front line of defense. As they did for the first time in weapons meet history in 1958 at "William Tell I," the top interceptor

(Continued on Next Page)

Poised like leashed greyhounds, Folcon-armed supersonic Delta Dagger F-102s wait the word to scramble after "invading" Firebees.

Deadly Sidewinder screams away from North American F-100 as it flashes across Florida skies in pursuit of the elusive Firebee.

teams of the Air Defense Command, from bases in the continental United States, Alaska, Europe, and the Pacific will pit their skills against the fast and elusive target.

The Firebee played a starring role in last year's meet, giving the pilots—as high-ranking officers put it—"the toughest challenge to combat proficiency ever put to test." This year the challenges will be even harder to meet. Pilots will be asked to fly new intercept tactics, including new angles of attack, new angles of interception and new types of team work. In addition to meeting one Firebee in broad daylight, they'll be challenged by Firebees in formation, and by Firebees flying at night.

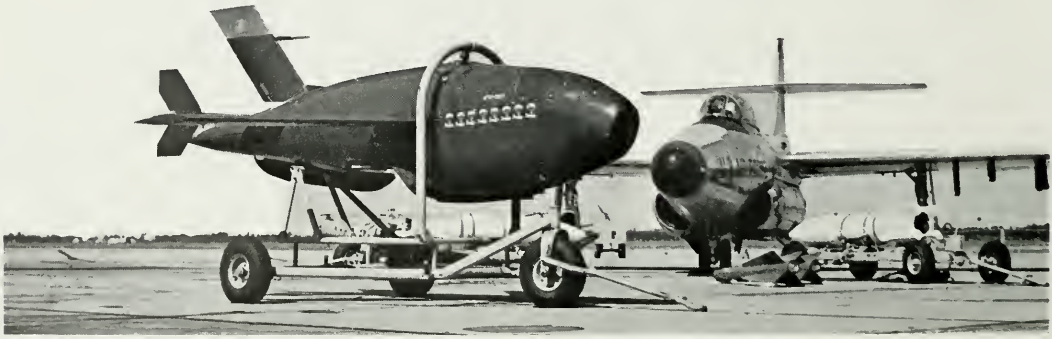
Without warning, the jet targets will swoop in in pairs at high altitudes (above 30,000 feet), come in as single targets at the same altitudes, and as single targets at low (5-15,000 feet) altitudes. At night, the interceptors will be forced to find the Firebee at altitudes above 30,000 feet.

The Firebee is a 600 mph jet-propelled airplane, whose small size can be "puffed up" to B-52—or Russian Bison —size though the use of self-carried radar augmentation devices. Capable of flying at very high altitudes for more than an hour, the Firebee can be safely parachuted to earth to be re-used over and over.

It is the nation's favorite target. Nearly every weapon that the Air Force, the Army, and the Navy possess has been used against the bird, ranging from .50 caliber machine guns to Nike-Hercules guided missiles, and including 3″ anti-aircraft guns, Sidewinders, Falcons, Genies, and Terriers.

The ability of the Firebee to fly for long periods of time, and to be recovered by parachute at the end of a mission make it one of the most economical means of testing the nation's weapons. Once launched, the fast-flying target can stay "on station" while as many as 10 interceptors make their passes. In many cases, the cost of a Firebee, per mission, is much less than the cost of the missile fired against it.

The built-in ruggedness of the Firebee helps it maintain its long on-station time. Firebees have sustained direct hits from missiles and have flown on with shattered fuselages and broken turbine blading.



Many-missioned Firebee (note decals) is given close scrutiny by an opponent, an F-89J Scorpion with a Genie missile under its wing.

Sharpshooter gets a close look at the target he won't see in action. Jet ace Major Ralph Parr, USAF, won't have any visual contact with the Firebee, will be radar-guided to "enemy".

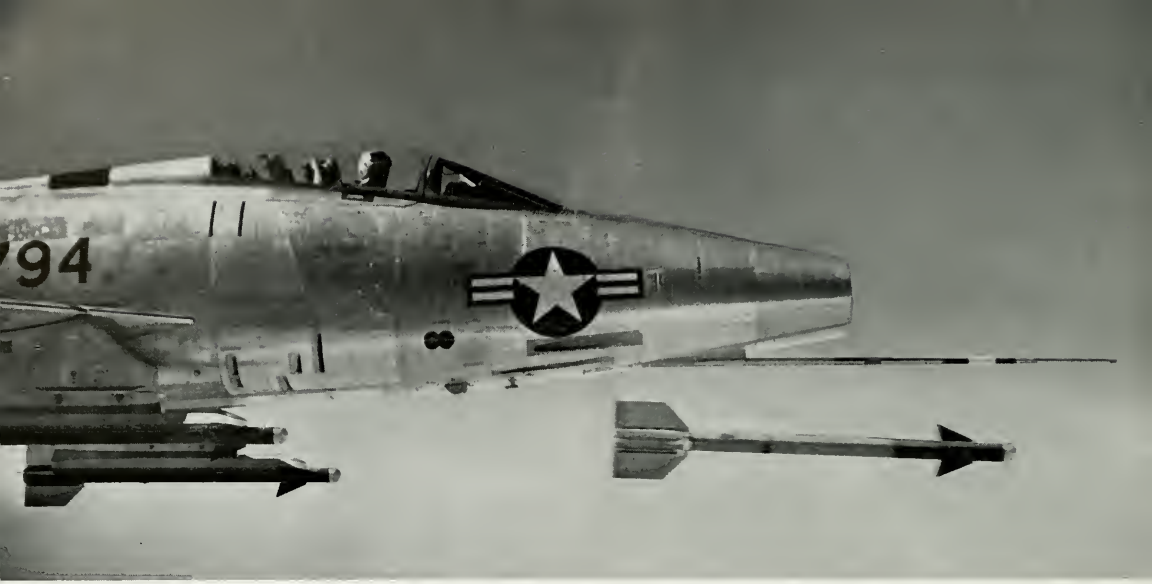
Flames from F-89J afterburners shred the night as Scorpions roll into scramble position to meet the challenge of a new problem, that of flying sorties at night against the Firebee.

A direct hit on the little bird isn't common, even though the augmentation systems in the Firebee do increase its radar image size. In order, then, to realistically evaluate the skill of the interceptor pilots, electronic scoring systems will be used at "William Tell 11". One system, called PARAMI (Parsons Ring-Around MIss distance) instantly transmits to ground recording stations the distance by which a missile speeds by the Firebee. Thus, if a Falcon comes within the lethal "envelope" of the Firebee, the pilot is credited with a hit, and the Firebee escapes unharmed, or remains on station for further intercept runs. The PARAMI will be used to score the Falcon and the Sidewinder.

For the Genie, a new scoring system, called MATTS (Multiple Airborne Target Tracking System) developed by Cubic Corporation of San Diego will be used. The Genie, when equipped with its nuclear warhead, is destructive over an extremely wide range. A Genie which passes within 500 feet of the Firebee is credited with a hit.

(Continued on page 28)

Plucked from a watery grave by 'copter, downed Firebee will be flown back to base for rehabilitation, to be used again and again.



Heat-seeking Sidewinder streaks away for a sure kill after being unleashed from its supersonic carrier, the Super Sabre F-100C.

PROJECT "WILLIAM TELL II"

CARRIERS AND

FOUR types of America's top interceptor aircraft will howl into Florida skies in search of the Ryan Firebee in Project "William Tell II," this October. Manned by crack pilots from the Air Defense Command, the Alaskan Air Command, the European and Pacific Air Forces, and the Air National Guard, the fleet planes of these commands will hurl MA-1 Genie, GAR-1 and GAR-2 Falcon, and GAR-8 Sidewinder missiles at the Firebee. The four aircraft will be the F-89 Northrop Scorpion, armed with the Douglas MA-1 Genie rocket; the F-100 North American Super Sabre, armed with the GAR-8 Sidewinder; the F-102 Convair Delta Dagger,

Armed with the free world's most widely used weapon, the Sidewinder, the free world's fastest operational jet fighter, the F-104 Starfighter, prowls for a target. Right: A USAF pilot displays the slim, accurate air-to-air missile.

Air Defense Command's prime interceptor, the all-weather supersonic F-102A Delta Dagger, cuts loose one of its nest of Falcons. The Dagger carries several of these supersonic guided missiles (left), which home by either radar or infrared.

WEAPONS

armed with the GAR-1 and-2 Falcon; and the F-104 Lockheed Starfighter, armed with the GAR-8 Sidewinder.

Long-range F89J Scorpion carriers nuclear stinger, the Genie, whose atomic warhead can knock down entire enemy squadron.

SCORPION-GENIE

Called "Scorpion" because of its unique up-swept tail assembly, the F-89J carries an awesome stinger, the MB-1 Genie. The Scorpion flies at speeds over 600 mph, can reach altitudes above 45,000 feet, and has a range of over 1000 miles.

The big plane carries both pilot and radar observer, and has been on operational status since 1956. It now flies cover for the Air Force at many bases in the United States, Alaska and the far north.

The Genie, with its nuclear warhead, is perhaps the most lethal air-to-air missile in the western world. It has been in squadron service since January, 1958.

First fired from an F-89 Scorpion

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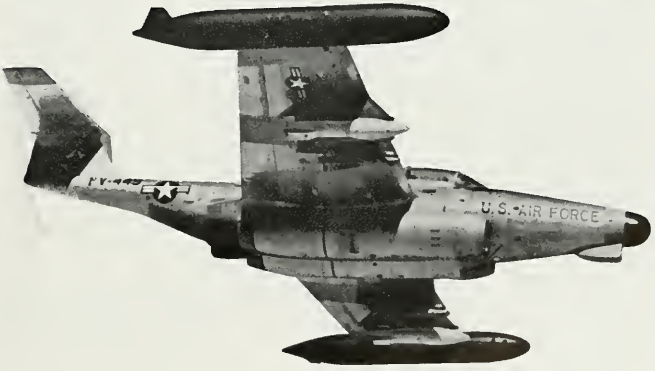

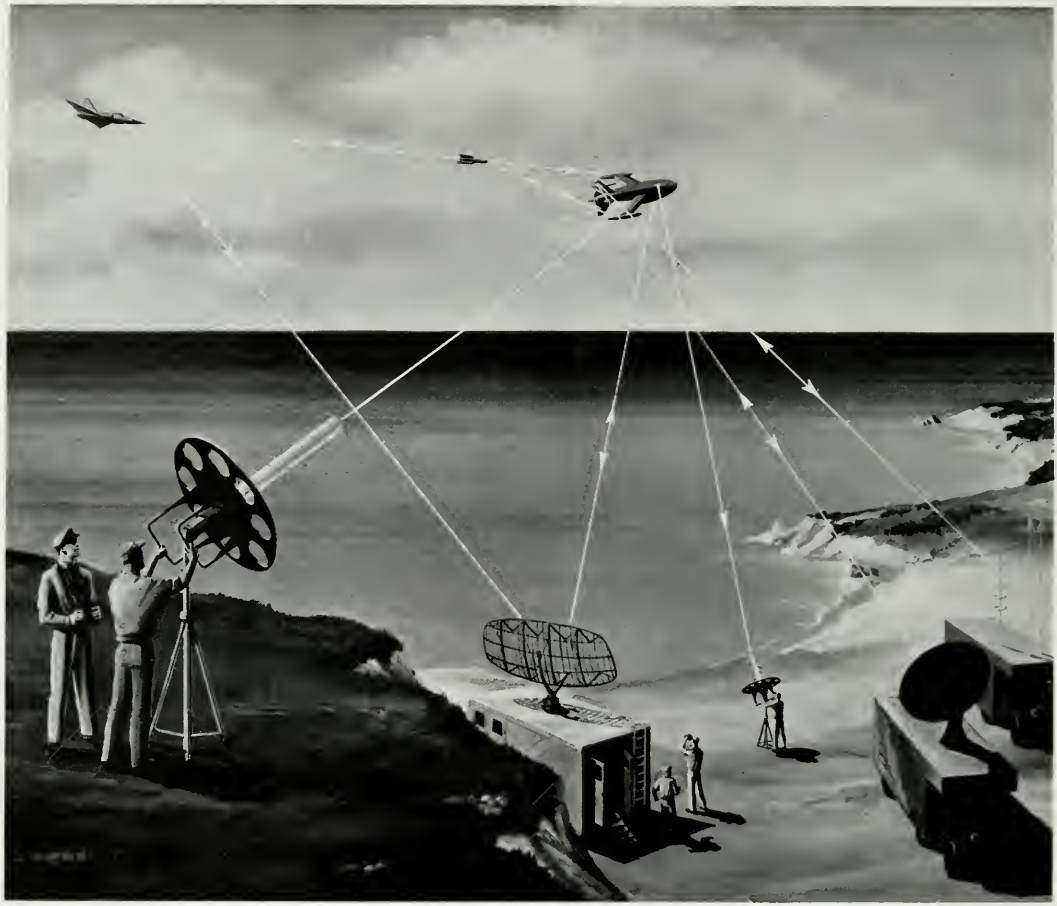

Radio-controlled Firebee flees from radar-guided missile fired from radio-vectored interceptor. PARAMI radar system scores hits.

PROJECT "WILLIAM TELL II"

ELECTRONIC SCORING

RYAN Firebees will mean double trouble for interceptor pilots at Project William Tell II. This year, to make the intercept problem even more realistic, pilots will scramble their ships in an effort to find and "destroy" two of the jet-fast targets at once. The Firebees will be launched at varying altitudes and distances.

To handle the scoring problem caused by the multiple targets, the Air Force has installed a new "miss-distance" scoring system developed by Cubic Corporation of San Diego. Called MATTS (Multiple Airborne Target Tracking System), the new device will tell instantaneously whether a pilot scored a hit or miss against the "enemy."

MATTS consists of a transmitter installed in each Firebee, which directs signals — calibrated at one megacycle apart for each Firebee—to ground stations. Each Firebee directs its signals to two ground stations, located some distance apart, enabling the stations to get an accurate fix on each Firebee's

position. The stations in turn feed this information to a computer located at a third point. The computer also keeps radar watch on the attacking missile, and, at the time of missile burst, calculates the relative position of missile and targets, giving an immediate read-out of the effectiveness of the attackers.

The MATTS scoring system and its companion system PARAMI are necessary because the Firebee, through radar augmentation, simulates an airplane many times its size. Therefore, a "hit" is scored if a missile comes within lethal range of the Firebee.

And, while the missiles used at "William Tell" will not carry warheads, in actual warfare an air burst can be lethal at ranges varying from 10 feet to several hundred yards. This is especially true of the atomic-warhead Genie, whose awesome blast can bring down entire formations of aircraft at long range.

PARAMI was used at "Propect William Tell I". Made by the Ralph M. Parsons Company, it is capable of accurately measuring the separation between the Firebee and an attacking missile from 10 feet to 3,000 feet.

PARAMI's airborne equipment consists of a transponder in the Firebee, and a much smaller transponder in the missile. Two carrier frequencies are used as the link between the airborne transponders, both of which contain distance information in the form of pulse-frequency. The Firebee, with its stronger transponder, is used to relay necessary telemetering data to the ground recording station. The ground station then transmits a coded, calibrated signal to the target.

PARAMI is a pulse system that is linear with miss distance. At the ground scoring station, it instantly and continuously records the changing distance between missile and Firebee and coordinates this data with actual elapsed time. The loop frequency of the two airborne transponders is a function of the mixed circuit delay time and the propagation delay time due to separation of the two transponders. This makes it possible to obtain missile-target distance not only at the point of closest approach, but prior to and after intercept.

Ranges from zero to 200, 500, 2500, and 5000 feet are available with different missile transponders. The system is accurate for velocities up to 3,000 feet per second with an error of plus or minus six feet.

In operation, the Firebee transponder continuously transmits a signal with a frequency of 265 megacycles. When the missile transponder comes within range of the Firebee's transponder, it receives the 265-megacycle pulse from the Firebee and retransmits the pulse on a frequency of 324 megacycles. This new pulse is received by the Firebee, which in turn transmits the pulse on the original frequency of 265 megacycles.

The two transponders are now locked in a "ring-around" frequency, which increases as the missile approaches the Firebee. The ground recording station receives the target signal and modulates it with a special frequency dependent on target-missile range. The range separation shows on the ground recorder

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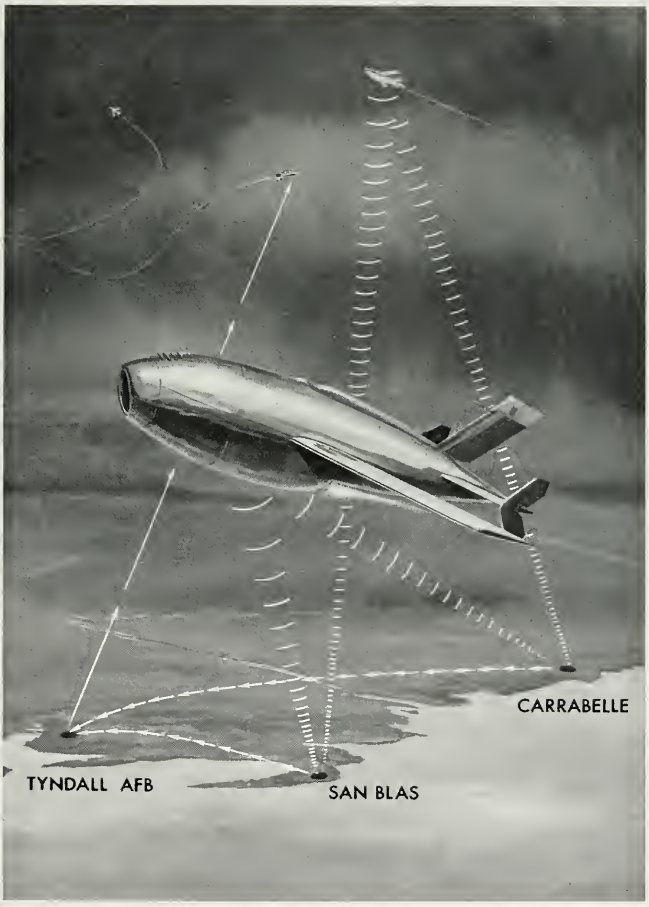
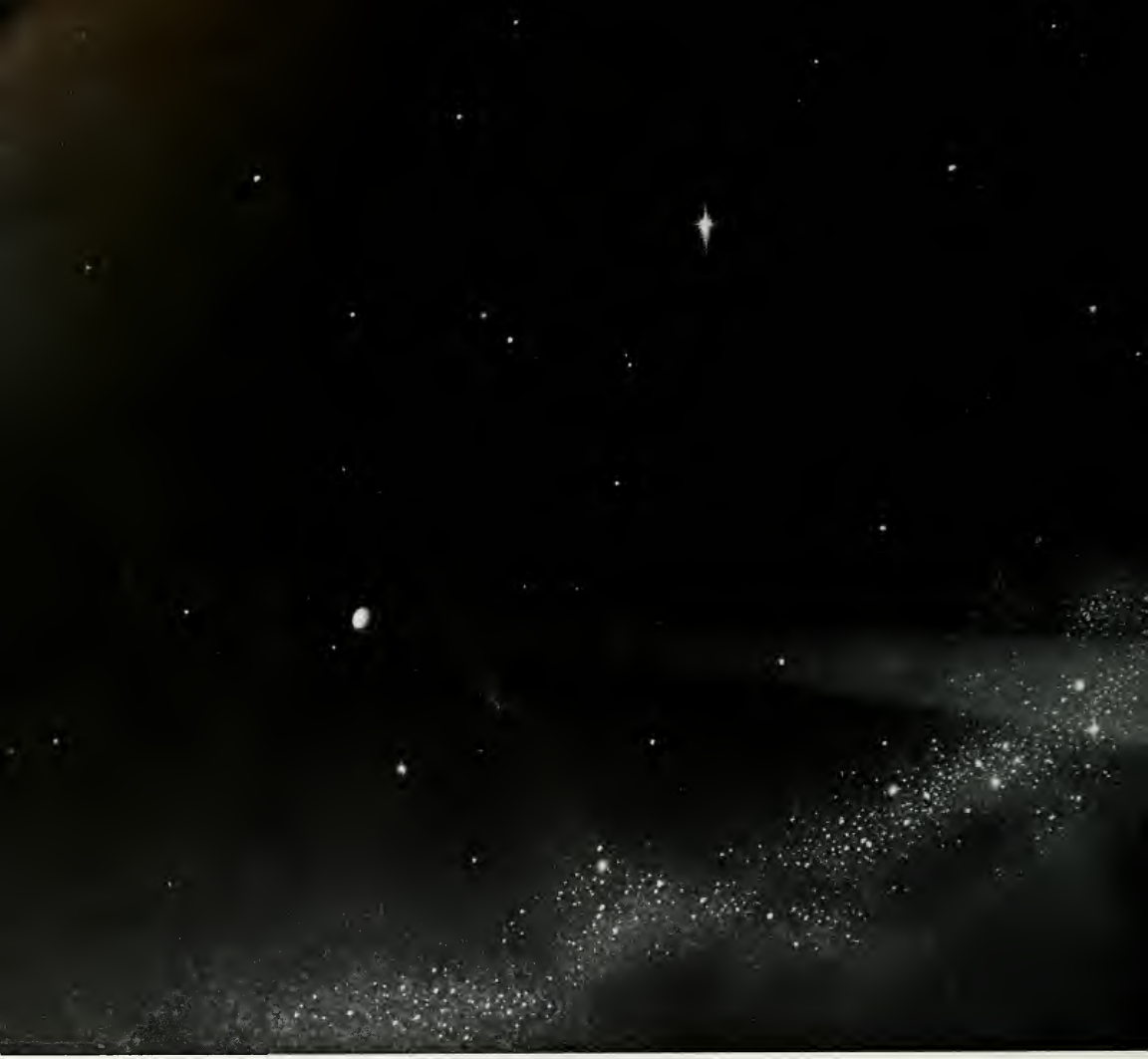


MATTS system scores hits against "double trouble" formation of Firebees in test of atomic-tipped Genie. System pin-points position of Firebees by triangulation, follows Genie by radar, determines if simulated atomic explosion was effective.



SPACE NAVIGATION

Ryan C-W doppler systems will be microwave highway in space

By Meredith Beyers, Research Engineer, Ryan Electronics Division

"I will find a way or make one"—Hannibal

WHETHER man stumbles as he steps between the planets, or whether he survives his journeys and returns to earth very much depends on just how good his navigation system is. The human navigator of a space ship may be able to see his destination, as well as the sun and its planets and the background of stars. But, until man has proved his capability in space, a completely automatic navigation system must be provided.

Existing Ryan doppler navigating equipment is even now capable of self-contained automatic guidance of the launching and terminal phases of space missions between the earth and moon or any other planet. By substituting a solar referrent for the terrestial gravitational vector and supplementing active radar with passive radar for mid-course guidance with the

(Continued on Next Page)

aid of electronic or ballistic steering, there is every reason to believe that C-W doppler will be able to meet the challenge of space navigation.

This automatic navigation ability, which will give celestial position indication and controlled release of critical directional thrusts, is an absolute necessity so long as it is necessary for man to conserve fuel through his space journeys by riding natural trajectories and gravitational gradients. Accuracy requirements for launching-parameters in space navigation are severe. An error of one foot per second in final launching speed means a miss of 25,000 miles at Venus, for example. The probable error of precalculated trajectories is even greater; we do not know where Venus is, within 50,000 miles or even more. Space vehicles would need to alter course during flight to correct for all these navigational and ballistic errors. Such corrections cannot be made unless there is provided continuous knowledge of position and velocity . . . not only speed, but the direction of motion with respect to origin and destination.

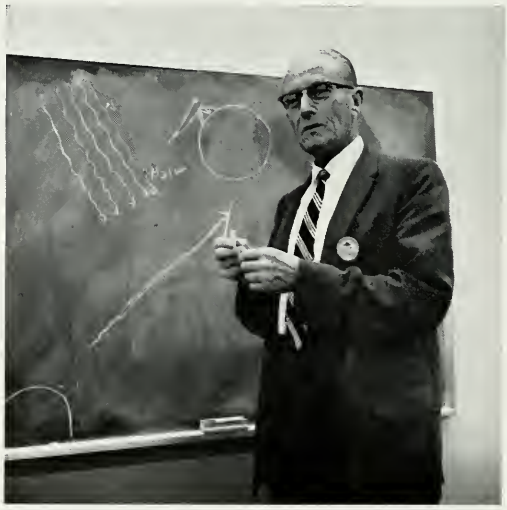
This is the challenge to radar as a space navigational aid. Present missile guidance systems are admittedly not capable of injecting space vehicles into interplanetary orbits with the accuracy required for advanced space missions. Inflight guidance commands must come from signals processed by a guidance computer. Can the necessary input information (position and velocity as functions of time) be obtained by the utilization of microwaves in space?

A number of organizations are investigating such problems. Ohio State University, conducting research on navigation techniques for interplanetary space flights, is examining all potential sources of space navigation information. Arthur S. Cosler, Jr., executive director of Ohio State University's Mapping and Charting Research Laboratory, concludes that even though chances of hitting a planet with a ballistic shot are slim, a manned space vehicle capable of inflight corrections could reach a planet with existing navigation equipment, and that there is little chance of a manned rocket becoming lost in outer space provided the vehicle could manage to carry all the standard navigation aids now available.

Ryan, in the Advanced Design Section of its Electronics Division, is studying applications of C-W (continuous wave) doppler techniques to the terminal phases of space missions. The guidance instrumentation will involve sensing (1) the vehicle's velocity vector relative to the body of destination, (2) the altitude with respect to the velocity vector, (3) the position with respect to the chosen sphere of reference. One approach that would be useful in achieving direct hits or specified orbits requires the use of radar beams to sense and control each velocity component independently. An alternate approach requires the use of a single gimballed radar beam to seek, track and control a desired velocity vector.

As a result of developments in the utilization of doppler effects to measure relative motion, and electronic techniques of accurately measuring small increments of time, microwaves provide a new tool for the investigation of many aspects of space and cosmological theory as well as a means of space navigation.

Microwave techniques have been recently employed by scientists of Lincoln Laboratory at M. I. T. to determine the distance to Venus within 200 miles. The echo time lag of 2.6 seconds for the moon, 5 minutes for Venus, 9 minutes for Mars and several hours for the outer planets presents a difficulty in applications for purposes of communications and navigation. Self-contained inertial guidance systems are compromised beyond the gravitational field of a planet because these systems seek a vertical reference which is defined by the gravity vector. Interplanetary navigation requires stabilization in a solar or stellar reference frame for mid-course guidance. In outer space travel, conventional methods of navigating are not expected to be sufficiently accurate. It is thought that space navigation will require a great revolution in the science of automatic navigation, that the rudimentary navigational techniques now being used will soon become inadequate, that vehicle control by radar tracking and radio command will lose its effectiveness because of the square law degradation of radio signal strength with distance. A self-contained guidance system is needed which can provide very precise control of the velocity vector.



Author Beyers outlines the application of the Ryan navigation systems in conquering the challenge of the vertical frontier.

Can these problems be solved with equipment and knowledge now available? ARPA director Roy W. Johnson confirmed at a press conference last year that the United States will undertake a program for sending probes to Mars and Venus. Dr. Ernst Stuhlinger (U. S. Army), in speak-

ing of the difference in pay load between a Mars probe and a Lunar probe explained that batteries must be designed to trigger the instruments after the vehicle has traveled for some 259 days. "This means more complex instrumentation," he pointed out, "but we know how to do it, and we can do it now."

Man is the decision maker, whether he be on the spot to react to immediate information or whether he is required to make predictive decisions in equipment design. The "breakthrough" necessary for travel between the planets—and perhaps even further—is a reversal of the current trend toward a greater complexity of design. The very foundations of modern physical theory are now facing questions that foreshadow another major theoretical adjustment which may have repercussions in the area of microwave theory and application.

Do electromagnetic radiations of various wavelengths all travel at the same velocity? In recent years no one has doubted it, but Dr. Edward Teller would like to test this theory by sending an atom bomb by space probe to be exploded 100,000,000 miles away. The resulting instantaneous release of radiation of many wavelengths would launch a race to earth that may have no winners; but, if it has, the future of radar may be changed by the discovery.

Is gravitation electromagnetic? There is evidence that it is, and that the so-called gravitational constant is numerically constant only locally; that we must look for an aberration of gravitation, just as we looked for and found the aberration of light; that the presumed law of independence of motions does not hold at high velocities, and that all precalculated trajectories of space probes will be in error without these considerations.

Men think with what they have acquired. They acquire and quote what they have learned from the literature or gained by experience in working with hardware. The next "break through" must come from men who think in terms of the frontiers in all the sciences, and who will perceive the part that radar can play in space navigation in terms and concepts with which we are not yet familiar.

RYAN VERSATILE VE

Ryan awarded design study contract for unique VTOL/STOL plane

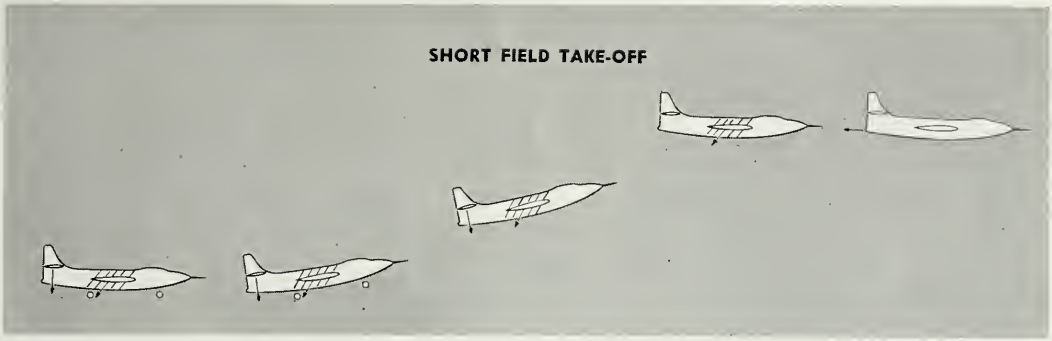
VERTIFAN, Ryan Aeronautical Company's new fan concept of combining vertical take-off and landing characteristics with high speed forward flight, has been recognized by the Air Force with award of a preliminary aircraft design study contract.

Principles of the Ryan Vertifan system have been under development since 1955 with the company's own funds, as part of its broad pioneering in various phases of VTOL (vertical take-off and landing) and STOL (short field take-off and landing) aircraft research. The General Electric Company will work with Ryan on this new program.

This system's distinctive feature is a fan, or set of fans depending on configuration of the plane, horizontally "submerged" within the wing and powered by a tip turbine, driven by the jet engine exhaust, to provide the lift for vertical take-off and hovering. In normal horizontal cruise, the power of the jet engine is diverted from the fans to straight thrust. The Vertifan system is applicable for use in conventional jet aircraft.

The jet engine serves a dual function. It provides conventional jet thrust for normal flight, and furnishes exhaust gases which are conducted to the fan by means of a thin curving pipe, or "scroll", into a turbine mounted on the periphery of the fan.

Above and below the fan, mounted



Upper wing vanes slant forward, lower vanes slant aft when Vertifan-equipped planes leap off runway during short field take-off.

on the upper and lower surfaces of the wing, are moveable shutter-like vanes which deflect the mass flow of air from the fan whirling at high speeds.

For vertical take-off and hovering, the vanes would be in a vertical position. For forward flight, the upper vanes would slant forward and the lower vanes would slant aft, deflecting the slipstream during transition from vertical to horizontal flight.

When the pure jet operation goes

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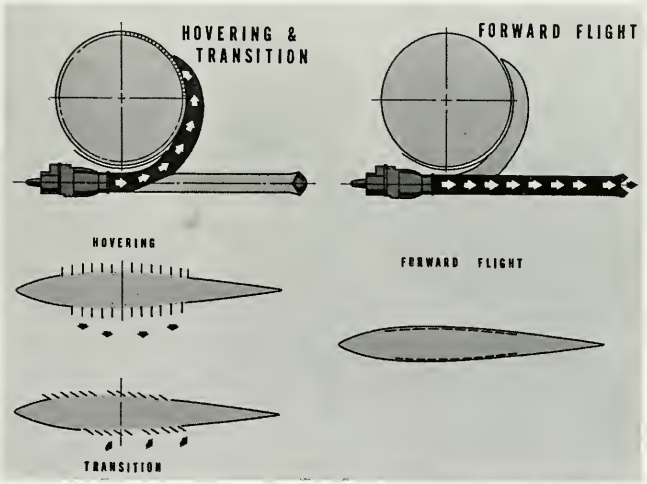
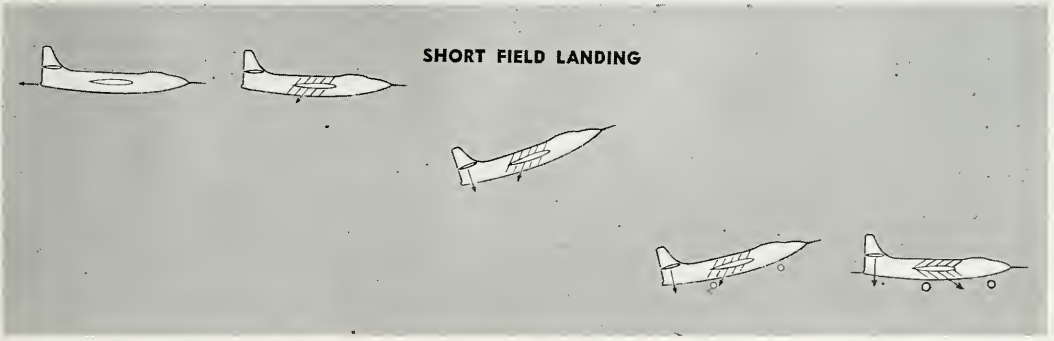
IFAN

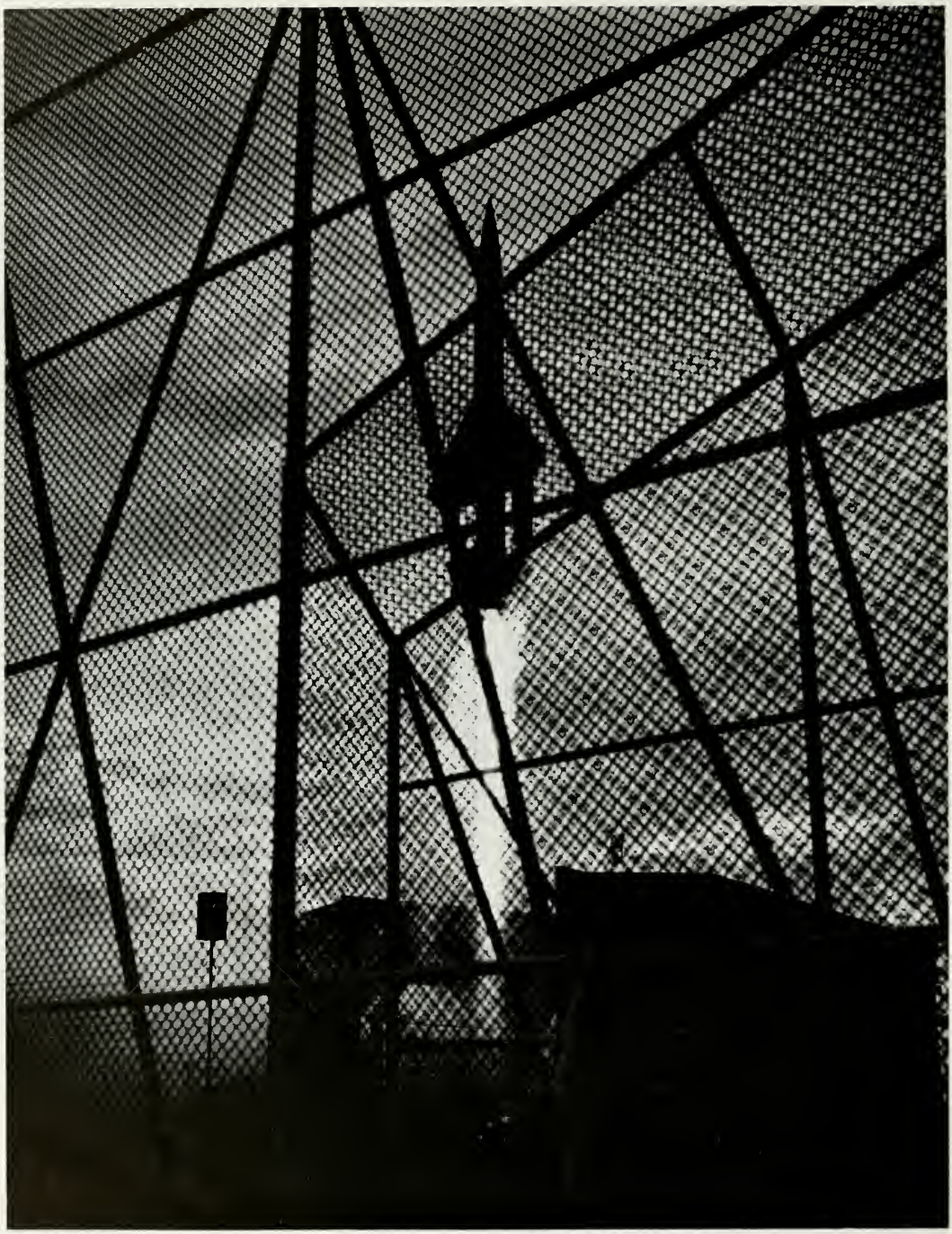


For VTOL/STOL flight, jet exhaust gases are diverted to fans buried in wings, and vanes open to proper position for hovering or transition flight. Vanes close and jet exhaust gas goes straight through for high speed forward flight.

**Trademark*

Short runways present no problem to Vertifan. All wing vanes slant forward at touchdown to aid in deceleration, shorten roll-out.





BOMBER BLASTER

Ryan-built combustion chambers corral the nearly 50,000 "horses" raging in the mighty Marquardt ramjets on the Bomarc

AN operator, tensely observing a radar screen in Kingston, N. Y., checks other instruments, then pushes a button marked—"Fire"—on his control panel.

Fifteen hundred miles away at Cape Canaveral, Florida, a Bomarc "A" missile jerks to life on internal power, starts its subsystem and completes final checks. The roof sheltering the missile slides back, the launcher-erector raises to a vertical position, then drops back empty as the Bomarc's ramjet flares are ignited.

Five seconds later, red fuming nitric acid and aniline furfuryl alcohol mingle in the missile's Aerojet-General rocket chamber to start the booster engine. A blinding light penetrates the murky early morning darkness, and, seconds later, the Bomarc interceptor missile eases off its launching pad belching a seething white hot tail of exhaust gas.

As the Bomarc leaps vertically from its shelter, it rolls to present its top surface to the attacking enemy and, as it reaches cruise altitude, pulls over in an Immelman turn to roll out headed toward its target.

The two powerful Marquardt ramjets strapped to the Bomarc's sleek fuselage, ignited a few seconds before lift-off, gulp huge draughts of air as

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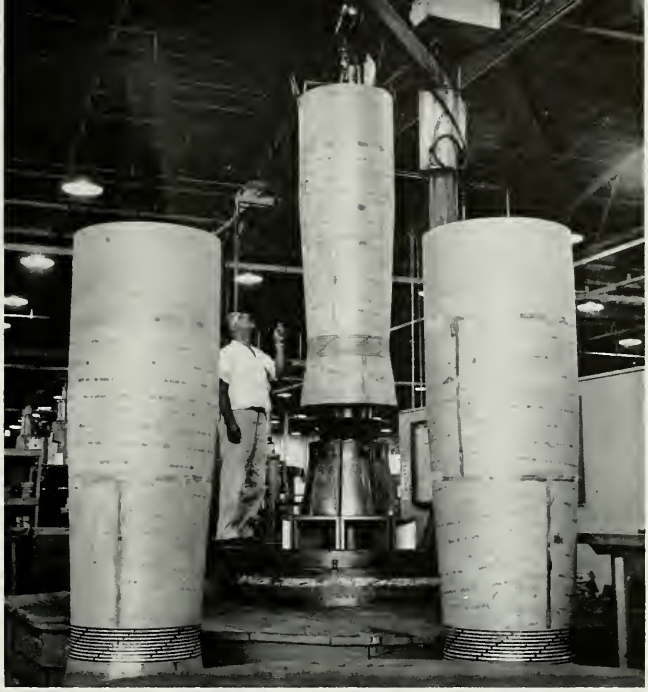
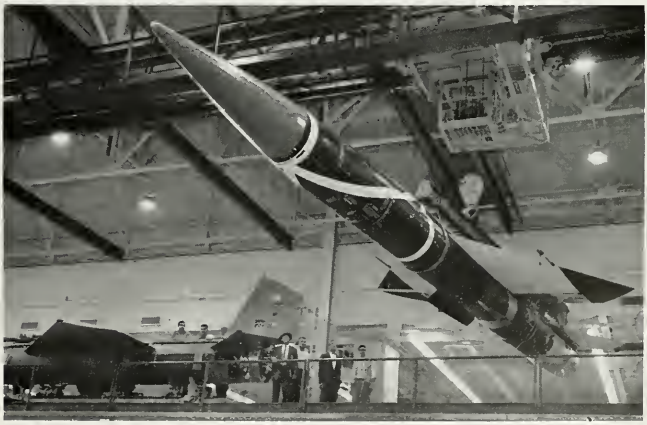


RJ43 Marquardt ramjet sections receive final tolerance checks on the Ryan production line. Expanding mandrel sizes engine's double seamed throat area.

Forty-seven feet of sudden destruction to attacking aircraft is readied for move from Boeing to launching site, where pilotless interceptor stands constant guard.



Bomarc booster rocket trail blasts thru the pre-dawn darkness as the bird leaps from its launching pad in a test firing.

Technician tethers a jet in Ryan test cell, readying engine for test of exhaust system being developed for Grumman attack plane.

JET TAILPIPE BY DYNAMITE

Ryan receives Grumman contract to build jet STOL components

Ryan exhaust system will give new Grumman plane short take-off ability, highly important in carrier operations. Plane will join these S2Fs, shown on *Princeton*.

RECENTLY, a Ryan engineer peered through the safety glass of the firing shed at Ryan's high energy forming site. His hand closed a switch, and an explosion of gelled dynamite thumped the ground softly.

The dynamite—about 10 cents worth —had accomplished in a split second what would have taken days, using

gigantic presses costing many thousands of dollars. It had also formed a part to a degree of perfection that the great presses probably could not have attained. The tremendous pressures, developed so quickly by the explosive, had formed almost instantaneously an important component of a tailpipe destined for a new attack aircraft being developed by Grumman Aircraft Company.

The tailpipe section, made of heavy gauge—.063 inch—high temperature alloy, was held to a diameter tolerance of two thousandths of an inch. There was no springback, and the metal fitted exactly the ductile iron die which surrounded it.

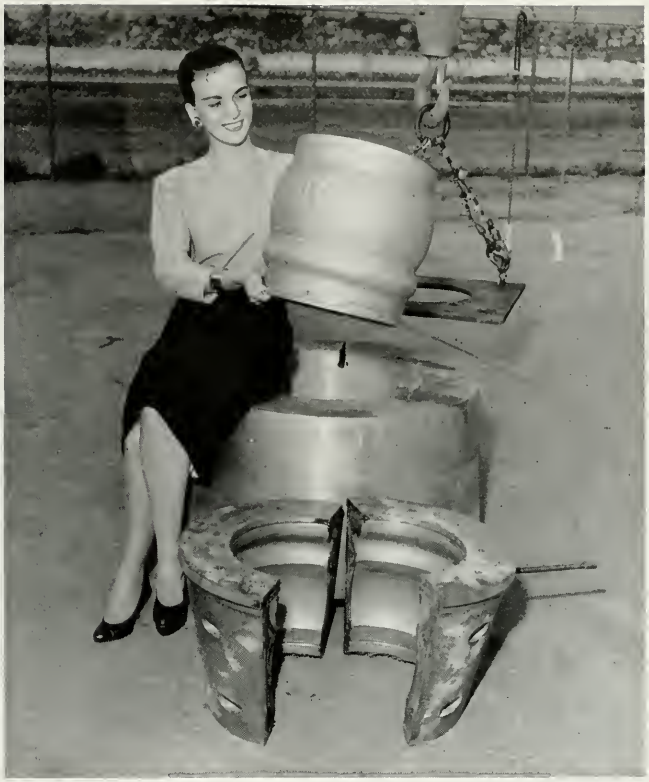
The part was moved from the forming site to its place in the tailpipe, and here explosive forming paid another dividend. The part mated so perfectly with its partners that it was not necessary to finish machine the mating surfaces. The fit was so close that leakage around the periphery of the joint was forty percent under the rate specified.

While forming hard-to-handle high temperature alloys to precise tolerance with conventional techniques has been a point of pride with Ryan for many years, the company started forming parts with explosives but a year ago.

Although high energy forming had been used for some years in simple blanking, dimpling, and piercing, little information was available concerning the amount of explosive, the depth of water, or the placement of the explosive near the part to be formed.

Ryan engineers were so successful in establishing these parameters, in nearly all types of metal, ranging from aluminum to the hardest of the new space age alloys, that the company soon became one of the very few in the aviation industry to form parts on a production line basis. A part for the nose cowl of the DC-8, pods and pylons for which are being made at Ryan, is formed with the new method.

High energy forming handles almost any metal, and forms it into shape, with astonishing speed, ease, and economy. It isn't necessary any longer to hit a part several times, with long waits between hits, while the metal, work-hardened on the drop hammer, is being re-annealed. Tolerances which would be almost impossible to meet with conventional forming methods are met with ease with high energy forming.



High energy shock wave slams heavy, extremely hard alloy—from which Grumman tailpipe is made—into shape at precision tolerances (.002 inch) in a split-second. Ryan's Dorothy Pantazis displays part formed early in explosive program.

The explosively-formed section is part of a special type jet engine tailpipe which Ryan is designing and building under the terms of a $500,000 research and development contract awarded by Grumman. The new tailpipe will help provide unusual performance capabilities for the new Navy A2F-1 carrier-borne attack planes.

Through an ingenious arrangement, the tailpipe will enable the plane to make extremely short take-offs and landings. Ryan is a pioneer in this field, having successfully developed for the Air Force the revolutionary Ryan X-13 Vertijet, world's first jet vertical take-off and landing aircraft, and the Model 92 Vertiplane, now being developed for the U.S. Army and the Office of Naval Research as a short take-off and landing plane.

Testing of the first unit built under the contract is now under way in Ryan's vertical jet engine test cell, with the use of a Curtiss-Wright J-65 turbojet engine. Eventually, it will be used with the exhaust of a Pratt & Whitney

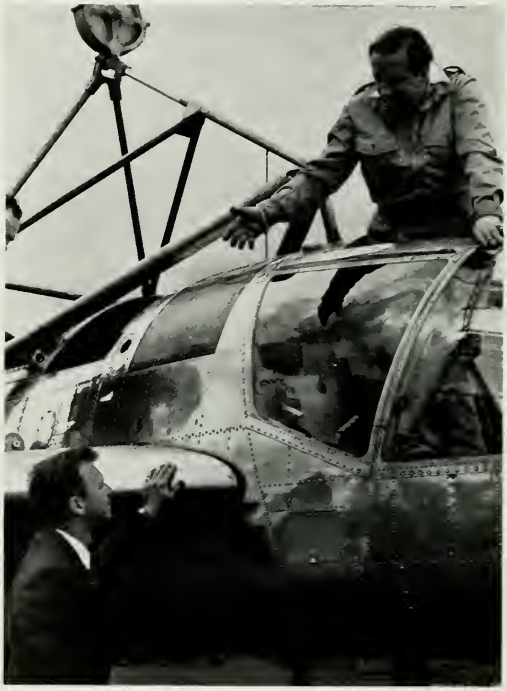
(Continued on Page 28)

Lou Everett delivers VTOL lectures to AGARD—IAC groups during European tour

EUROPEAN aircraft manufacturers have interesting concepts of VTOL (vertical take-off and landing) and STOL (short take-off and landing) designs, but appear to be lagging behind U. S. companies, such as Ryan, in development work.

This was one of the observations brought back home by W. L. "Lou" Everett, Ryan engineering test pilot, after a several weeks tour of plants in England, Ireland, West Germany and France. During his recent European visit, Everett presented scientific papers on Ryan's VTOL and STOL experience at two major meetings. He addressed the Advisory Group for Aeronautical Research and Development, an agency of the North Atlantic Treaty Organization in Athens, Greece, and the International Aeronautical Congress in Paris. The papers were prepared by Peter F. Girard, Ryan chief engineering test pilot, who was unable to make the trip.

In France, Everett viewed the SNECMA coleopter, which has an annular wing enclosing the portion of the fuselage containing the power plant. The coleopter is a vertical attitude jet VTOL using the jet reaction principle



Lou Everett (left), Ryan Engineering Test Pilot, chats with Mr. Tom Brooke-Smith, Chief Test Pilot of Short Brothers & Harland in Belfast, Ireland. Airplane is SB & H, SC-1 jet VTOL craft.

RYAN TEST PILOT TALKS TO NATO

for control, similar to the Ryan X-13 Vertijet. The plane has flown vertically, but had not made a horizontal transition.

In Belfast, Ireland, Everett saw the VTOL aircraft of Short Brothers & Harland, which uses the thrust of 4 pure jet engines, buried in the fuselage, for vertical lift in a horizontal attitude, and one jet engine for horizontal flight. The four small jet engines buried in the fuselage weigh only 200 pounds each, yet put out 2,000 pounds of thrust each. Bleed air from the 4 lifting engines is fed through ducts in the wing-tips for roll control and the nose and tail for horizontal transition.

"Hawker Aircraft Co., Ltd. of England also is planning a VTOL, details of which are restricted," the Ryan pilot said.

In Germany, Everett flew the Dornier DO-27, a 6 passenger plane with approximately the same weight and power plant as the Ryan Navion and which has excellent STOL characteristics.

Dornier is flight-testing a twin-engined, propeller-driven experimental DO-29, which has tilting, pusher props that can deflect downward along with the wing flaps to give vertical lift. Flight-demonstrated at the Air Salon was the four-engined turbo prop Breguet high-wing STOL which, like the Ryan Vertiplane, utilizes the deflected slipstream principle through use of large double flaps.

In France, Everett flew the Hurel Dubois HD-34, a large twin-engined plane having a very high aspect ratio wing. It takes off and lands slowly, and "flies like a glider" with power off. In England, he also piloted the Miles Student, a two-place jet trainer which has the same power plant as the Ryan Q-2A Firebee.

Back in the United States "Lou" spent two weeks at Fort Rucker, Alabama in a helicopter indoctrination course, prior to beginning preliminary testing of the Ryan Vertiplane at the Moffett Field Naval Air Station in October.

RYAN VERTIFAN

(Continued from Page 19)

into effect for high speed forward flight, the upper and lower vanes are closed to produce a smooth wing surface, and a valve diverts the exhaust from the fan, directing it aft through the tail pipe nozzle.

For landing, the upper and lower vanes would open and slant forward to give a decelerating force, and would be moved to the vertical position as the aircraft's speed drops to zero.

Control and added lift would be given the plane by a small fan submerged in the horizontal tail.

Among advantages of the Vertifan concept over other jet VTOL, cited by Ryan engineers, are:

Gross weight can be considerably in excess of the jet engine's thrust, through use of the light-weight, thin fan within the wing, devoted entirely to vertical lift.

Since vertical flight in other jet VTOL concepts may require more than two to three times the thrust needed to attain maximum speed in level flight, conventional jet engines built to develop enough thrust for vertical take-off are too large and powerful for the most economical operations at cruising horizontal speeds. In the Vertifan concept, the jet engine size and thrust need not be increased over the requirements for level flight.

Extended periods of hovering will be made possible by comparatively low specific fuel consumption.

Principal advantage over propeller-driven VTOL aircraft is the Vertifan plane's greater speed range.

Ryan engineers foresee through use of the Vertifan principles elimination of expensive, fixed long runway bases, an improved flexibility of operations under emergency conditions, and an ability to disperse bases to avoid the vulnerability of air field runways to destruction by enemy missiles and aircraft.

The Vertifan concept is the latest in a series of Ryan VTOL developments which have attracted world-wide attention. The Ryan X-13 Vertijet, built for the Air Force, was the world's first pure jet vertical take-off and landing aircraft. It was successfully flown in an extensive testing program at Edwards Air Force Base, Calif., and was demonstrated before high-ranking Pentagon officials and members of Congress in spectacular flights at Washington, D.C.

The Vertijet is a delta-wing, high speed jet which takes off and lands in a vertical position.

Currently in a test program for the U. S. Army and the Office of Naval Research is the Ryan Model 92 Vertiplane, an aircraft of conventional configuration, powered by a gas turbine engine, and equipped with double, retractable wing flaps extending far below and to the rear of the wing trailing edge. The slipstream from two large propellers is deflected by these flaps to provide vertical lift when the plane is in a horizontal position.

Directors Appoint Jackson Executive Vice President

Robert C. Jackson has been named Executive Vice President of Ryan, T. Claude Ryan, President and Chairman of the Board, announced following a recent meeting of the Board of Directors.

ROBERT C. JACKSON
Executive Vice President

Jackson has been a member of the Ryan Board of Directors for the past two years, serving as Vice Chairman for the past year, a position he will continue to hold.

Ryan also announced that George C. Woodard, the company's Executive Vice President since 1947, would become Vice President and Executive Advisor.

"In moving from a position of direct operating responsibility to his new position, Mr. Woodard will be the firm's senior consultant on financial and business matters, and continue to serve as a member of the Board of Directors as he has for the past 17 years since first joining the company," Ryan said.

"Mr. Jackson's unusual business and management abilities adds materially to the top management strength of our fast growing company," Ryan said.

FIREBEE HIVE

(Continued from Page 2)

Ryan had to pioneer in the hot-forming of magnesium.

Some months ago, due to the demands for space by new projects at the main Ryan plant in San Diego, Firebee final assembly lines were moved to the Ryan Facility at Torrance. Although manufacturing of components and sub-assemblies is still done at San Diego, major assembly work and final check-out of the Firebee is done at Torrance. Assembly of the electrical harnesses — loops and lengths of wire that act as the target's "nervous system," is also done at Torrance.

At Torrance, to ensure that the Armed Services get a fully operational Firebee, the finished product is run into a "one-stop" check-out station. Here, operated from a single console, various instruments test out every component and flight system, including fuel, autopilot, and electrical components. The console can simulate various flight conditions, and can pin-point trouble spots immediately.

Analyzing trouble spots in electrical systems is also done automatically. A circuit analyzer which is plugged into the Firebee's wiring system automatically spots short circuits in the Firebee electrical circuits and indicates their position.

The 1100-pound-thrust jet engines also get a final check-out at the run-up cell at Torrance.

WILLIAM TELL I

(Continued from Page 6)

competed as single units. This system duplicated the Air Force's "round the clock" defense system in which these teams work together from "scramble" to "kill."

For the first time electronic scoring (PARAMI) was used to give an instant, accurate result of firing. Counting holes shot through a piece of canvas is no longer necessary.

For the first time the primary ADC interceptor, Convair's F-102 Delta Dagger, saw action in competition. This supersonic aircraft, with its brood of deadly Falcons, proved its worth and capability.

For the first time the Falcon was let loose in competition. It quickly proved its terrible effectiveness.

For the first time the Genie rocket entered competition. This missile can pack an atomic punch which can kill at a range measured in hundreds of yards.

For the first time, cameras mounted in the target missiles scored the effectiveness of attacking weapons.

For the first time, an interceptor smashed through the sound barrier in delivering its missiles. This occurred during the F-102 phase.

For the first time, television cameras covered every phase of the weapons meet. TV went aloft with every scramble, covered the ground control and radar plots, brought to the meet a unique, new method for evaluating the performance of pilots, planes and weapons.

For the first time in a weapons meet, the rules dictated that competing teams follow the air defense concepts of "Detection — Identification — Interception—Destruction."

The 4756th air-launched 78 Ryan Firebees during "William Tell I". To do this, to make sure that each target, its guidance system, its electronic and camera scoring systems, its parachute recovery system, and its radar identification beacons were in perfect working order, meant that the 4756th literally had to live with the Firebees.

New Military Relations Chief

John W. Rane, Jr., 41, has begun duties at Ryan as Director of Military Relations. He was formerly Director of Engineering and Sales, and Assistant Vice President of Bell Aircraft Corp., Buffalo, N.Y.

The new Ryan executive joined Bell 18 years ago, a year after graduating from the University of Michigan with a Bachelor of Science in Engineering. He held various engineering posts, including stress engineer and project structures engineer, until 1944, when he was commissioned a Navy officer with aeronautical engineering duty in the Bureau of Aeronautics, where he headed the structural design section, responsible for approving airframe designs of new naval aircraft.

Returning to Bell in 1946, Rane served as a sales engineer until 1950, when he was promoted to Assistant Director of Contracts. He became Director of Contracts and member of a six-man corporate policy committee in 1952. From 1956 to the present, he was Director of Engineering and Sales, aircraft division.

JOHN W. RANE, JR.
Military Relations Director

PROJECT "WM. TELL II"

CARRIERS & WEAPONS

(Continued from Page 11)

in July, 1957 at the Atomic Test Site in Nevada, the Genie was developed by Douglas Aircraft Company in cooperation with the Air Research and Development Command. The missile remains inert in a nuclear sense until it is armed in the air only a few moments before firing.

The Genie warhead is a miniaturized nuclear device with a sub-nominal yield. (A nominal yield is equivalent to 20,000 tons of TNT.) This sub-nominal yield is large enough to destroy all aircraft within a radius of several hundred yards, and accordingly the only guidance necessary is spin-stabilization and correction against gravity-drop by four fold-out fins. The Genie is powered by a highthrust solid-propellant rocket motor manufactured by the Aerojet-General Corporation.

SUPER SABRE SIDEWINDER

The North American Super Sabre F-100 will see service at "William Tell" under the colors of the Air National Guard. The first operational aircraft in the world capable of supersonic speed in level or climbing flight, the Super Sabre at one time held the world's speed record of 822.135 mph.

The Super Sabre gets extended range from a "buddy" system of refueling. One Sabre can refuel another, using a drogue and probe system. The "tanker" plane trails a hose and drogue from an external pod under the wing. On completion of refueling, hose and drogue are automatically rehoused within the pod.

The Sidewinder which the Super Sabre will use at "William Tell" is the free world's most widely used weapon —and one of its most effective in aerial combat. The Chinese Nationalist air force recently blasted 14 Red Mig-17s out of the sky in a single day, firing the deadly heat-seeking missile from F-86s.

Originally developed by the U. S. Navy, the Sidewinder is in service with the U. S. Navy, Marine Corps and Air Force, the air forces of Australia, Western Germany, Norway and Japan and the Royal Canadian Navy.

The missile is nine feet long and four and one-half inches in diameter, weighs 155 pounds and can attain a speed of Mach 2.5. Its range is about 18,000 feet.

In order to divert the infra-red seeker from the heat of the Firebee's jet engine, the Firebee will be equipped with heat flares attached to its wingtips.

DELTA DAGGER FALCON

The F-102 Delta Dagger is in service with more than 20 Air Defense Command fighter-interceptor squad-

(Continued on Next Page)

(Continued from Page 26)

rons from California to New York. First operational all-weather supersonic interceptor for the Air Force, the F-102A's electronic and armament equipment make it a lethal weapon in any kind of weather.

Developed by Convair for the Air Force, the plane was the first to incorporate the "coke bottle" fuselage, developed by the NACA. The area-rule construction, coupled with the F-102's Pratt & Whitney J-57 jet engine, enables the Falcon-carrying Delta Dagger to reach speeds of well over Mach 1 in level flight. Its service ceiling is above 50,000 feet.

The Falcon, with which the F-102 is armed, will be in two versions at William Tell. Dubbed GAR-1 and GAR-2 by the Air Force, the two weapons are, respectively, radar guided and infra-red heat seeking types.

In operation, the F-102's electronic control system locates a long-range target and directs the pilot on the correct attack course. At the right moment for intercept, the electronic control system arms and fires the missile automatically. The Falcon's guidance system—either radar or infra-red controlled—then directs the missile at supersonic speed to its target for the kill.

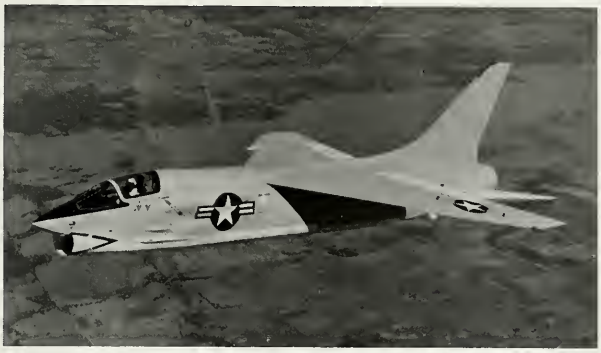
The Falcon has a solid propellant rocket engine which pushes the missile at speeds exceeding Mach 2. Control during flight comes from small forward fins and large aft stabilizers, with control surfaces attached to the rear of each stabilizer. Guidance, control and auxiliary systems are packed into a few feet of the body of the missile. Accuracy of the Falcon is attested to by the number of Firebees that have been destroyed by them, even though the Falcons were carrying telemetering equipment rather than tactical warheads.

STARFIGHTER-SIDEWINDER

The Lockheed F-104 Starfighter is probably the fastest and highest-flying interceptor in operational service in the free world. Holder of the world's speed record of 1404 mph; holder of the world's altitude mark of 91,243 feet; and holder of seven time-to-climb records, including 4 min. 26 seconds to 25,000 meters, the Starfighter is regarded as one of the most sensational planes of its type built since World War II. The Starfighter is powered by a J79 turbojet rated at 15,000 pounds thrust with afterburner.

In service with the U. S. Air Force, the Starfighter has also been chosen by the government of West Germany, by the Chinese Nationalist Air Force and by the Canadian government. The F-104 stands on guard at the extremes of the periphery of the free world.

Standard armament includes one 20 mm. Vulcan cannon, and Sidewinder air-to-air missiles. Only the Sidewinders will be used at William Tell.



1000-mile-an-hour Chance Vought Crusader is one of two types of Navy fighter planes which will fire missiles against Ryan Firebee jet targets in Operation "Top Gun," the fourth annual Naval Air Weapons Meet Nov. 30 to Dec. 4. Four teams of Crusaders will use Sidewinders.

RYAN 'BIRD' SOLE TARGET FOR MISSILES

An increasingly important role will be performed by Ryan KDA-4 Firebee jet targets in Operation "Top Gun," the fourth annual Naval Air Weapons Meet Nov. 30 to Dec. 4.

In addition to the Firebees' original assignment as targets for Sidewinder missiles fired from Chance Vought F8U-1 Crusaders, the speedy Ryan free-flying, remote-controlled "birds" will also test the marksmanship of pilots in McDonnell F3H-2 Demons using Sparrow III missiles.

Thus, the Navy has decided that the Firebee will be the only target used in the missile phases of the meet. Towed targets and ground targets will be utilized in the firing of rockets and conventional weapons.

The keenest fighter teams of the Navy and Marine Corps will be based at the Marine Corps Auxiliary Air Station, Yuma, Ariz., during the meet, but firing against the KDA-4's will be performed on ranges over the ocean off the Naval Missile Center, Pt. Mugu, Calif.

Utility Squadron Three at Brown Field, Chula Vista, Calif., will supply and operate the Firebee targets.

The Sidewinder missile, built by Philco, has a General Electric infrared guidance system which detects and homes on radiation from the target. The Sparrow III, developed by Raytheon, is guided by signals from the launching aircraft which control the missile's stub wings. It is powered by a solid fuel rocket.

Four teams of Crusader day fighters will fire Sidewinders. The Crusader set the first supersonic transcontinental speed record in history two years ago when it flew from Los Alamitos, near Long Beach, to New York in 3 hours, 22 minutes, 50 seconds, refueling three times en route.

Two teams of Demon all-weather fighters will shoot the Sparrow III against Firebees. The Demon combines interceptor speeds and fighter maneuverability with the payload of an attack bomber, and its radar assures all-weather and night operation ability.

FIREBEE AT "WM TELL II"

(Continued from Page 9)

Winning scores won't come just from accurate shooting, however. Points will be awarded for all of the various items which make up the complete combat effectiveness of an interceptor squadron. Only when all pilots and all planes are ready for instant take-off, only when all aircraft are in position for firing runs against the invading Firebee, is the intercepting team awarded a perfect score—providing it "knocks down" the target.

This is the "invasion" and interception pattern:

A B-26 launch plane, wearing two red Ryan Q-2A Firebees under its wings, moves out onto the Tyndall Air Force Base runway, runs up its engines, and then roars off down the runway and into the sky. As the white launch plane nears fifteen thousand feet, its pilot informs ground control that the bird has been checked out, its engine is running, and it's ready for free flight.

On command, the launch plane cuts the Firebee loose. It drops in a gentle glide for about 400 feet, then spurts up in a climb as the engine hits full rpm. Ground control takes charge, shoots the target up to 30,000 feet, and holds it at about 600 knots.

As the red bird streaks for the firing course, the meet judge, flying chase on the Firebee in a TF-102, closes in. It's the judge's job to scan the target, note if it is obeying the commands of ground control, and then to declare the Firebee a valid target. As the bird closes in on the range, the judge informs ground control and radar plot that this is indeed a valid target.

With this, ground control orders "SCRAMBLE!", and F-102's flash off the runway in pursuit of the Firebee. At mission altitude, the F-102 electronic aiming and firing system locks onto the target, and split seconds later, a deadly Falcon bares its talons as it reaches for the Firebee.

This time, it's not a matter for the miss-distance indicators. The heat-seeking Falcon smashes into the wing-tip flares of the target, tearing off the wing-tip. Ground control commands parachute ejection, and the bird swings down to the sea, to await helicopter pickup. The Firebee will then be returned to base for cleaning, repair, and re-use.

JET TAILPIPE

(Continued from Page 23)

J-52 engine, the power plant for the A2F-1.

Grumman is producing the new plane under a $101,700,000 contract from the Navy. Designed for high- and low-altitude operation, the carrier based aircraft will be powered by two turbojets and will be manned by a crew of two.

Ryan's part in producing the new plane has the potential for expanding into a volume production contract on the completion of the performance tests now in work.

GEARED FOR GUIDANCE

(Continued from Page 5)

ing, and the personnel department.

The organization at Torrance, where large scale manufacturing of Ryan doppler navigators is accomplished, is under the direction of H. M. Schiff, Operations Manager. The operation comprises manufacturing services, quality assurance, engineering and liaison, materiel department, personnel and related functions, and the production departments. The factory with its new and modern equipment and facilities is geared for high volume, high quality production of complex electronic components and systems. Every step of fabrication from wire stripping to final check-out is controlled scientifically.

The electronics test laboratory now nearing completion at Kearny Mesa, in addition to housing a complete environmental test facility, will accommodate micro-wave development, systems evaluation, a boresite tower range, field service, and customer training classrooms. The building itself has numerous unique innovations. The shaker area, for example, is a room within a room, so constructed as to reduce noise and vibration. The micro-wave test area, occupying a major portion of the second floor, is divided into six individual bays that open onto an unobstructed balcony, thus enabling micro-wave antennas to be tested with minimum interference.

PROJECT "WM. TELL II"

ELECTRONIC SCORING

(Continued from Page 13)

paper tape as a series of dots on specific points of the tape.

As the missile moves away from the Firebee after closest point of approach, the modulation frequency decreases until the signal is lost. The results of the ground station records the entire intercept, from point of acquisition through closest point of approach and back out until the signal is lost. The results of the intercept can be determined within seconds after firing.

BOMBER BLASTER

(Continued from Page 21)

the missile knifes through the morning sky. The air, forced into the Ryan-built combustion chamber to burn with 80 octane gasoline creates blast furnace heat, which is converted to blazing exhaust as the Bomarc gains momentum. Finally the Aerojet booster rocket burns out as the ramjets take over full propulsion, exerting 10,000 pounds of thrust behind the interceptor to hurl it at Mach 2.75 toward the target. Mission altitude—over 50,000 feet.

Nearing the target, the remote control operator checks his control panel again, and shifts control to the missile's self contained terminal guidance seeker.

"Locked-on," the missile pitches over in a dive on the target, passing close enough to destroy it, if the Bomarc were combat-armed with nuclear warhead and proximity fuse.

In this typical test mission, the Bomarc had been assigned to knock out a North American X-10 test vehicle. The X-10, launched from Cape Can-

(Continued on Next Page)

averal, flew out over the Atlantic and turned back for a mock attack on the missile base at a speed of 1,000 mph (Mach 1.6) and an altitude of 48,000 feet. Elapsed time from launch to intercept was five and one half minutes.

The Boeing Bomarc interceptor missile is basically a 15,000 lb. gross weight radio-controlled, pilotless airplane which is launched vertically by an Aerojet-General LR 59-AG-13 fully gimballed liquid propellant booster rocket. The Bomarc is powered in the cruise phase by two 28-inch diameter Marquardt RJ43-MA-3 ramjets which develop 10,000 pounds of thrust. Boeing officials say the Bomarc, with its range of from 200 to 250 miles, can provide effective intercept coverage of an area up to 500,000 square miles.

Ryan, long-time industry leader in hammering hard-to-form metals into sleek aircraft designs, fabricates the large "stovepipe" sections of the Marquardt ramjet, used to power the deadly interceptor.

Ryan's long experience in fabricating high temperature components proved invaluable in the production of the Marquardt chambers. These structures appear deceptively simple. Formed of N-155, a chrome, nickle, cobalt alloy, the ramjet "stovepipe" consists of four sections, which are rolled and welded longitudinally on automatic heliarc machines. All sections except one must be tapered to different angles, and each is of different thickness, running .051″, .063″, and .078″.

Nearly seven feet long, the entire assembly must be accurate in length to within .030″. This is a difficult specification to meet because the sections are welded together circumferentially, and a special doubler is welded over one joint. This requires substantial amounts of fusion and resistance welding which causes sizable weld shrinkage lengthwise. The shrinkage cannot be accurately predicted because of the variations in gauge thickness and taper involved.

The sections must be perfectly sized and mated in diameter before they are welded circumferentially, a tough task because of the pronounced "spring back" tendency of the N-155 alloy, a tendency which varies with gauge thickness and taper.

To provide a perfectly smooth internal surface for the converging-diverging combustion chamber, so that gas flows are not disturbed, Ryan welds must be controlled to within plus or minus .010″ thickness. All welds are rolled in Ryan seam rolling machines to produce a flush, stress-relieved cold worked joint.

The stovepipe, 28 inches in diameter at the widest point and 23 inches at the smallest point, is sized on an expanding mandrel after the doubler has been seam welded in the throat area.

Ryan craftsmanship is double checked in a strenuous quality control program performed at various stages in the fabrication. A final inspection is made before the finished part is shipped to Marquardt. Quality in Ryan welding techniques is insured by prompt re-certification of welders as well as frequent laboratory checks of the heliarc seam and spot welding machines.

The RJ43 ramjet uses no variable geometry in the inlet duct and maintains shock position by fuel flow control.

Bomarc reaches its maximum speed of approximately Mach 3 at booster burnout while it is still climbing. Because the longitudinal center of gravity is of little importance during the vertical phase of the flight, booster propellants are stored aft of the normal center of gravity. The missile does not begin to program over into level flight until the booster propellants are expended and the CG reaches an acceptable range.

Propellant combination is inhibited red fuming nitric acid oxidant, and JP-X, a mixture of JP-4 middle cut gasoline and unsymmetrical dimethyl hydrazine. Propellants are fed by helium stored under 4,300 psi. Booster ignition is provided by filling the fuel line between the fuel tank and the ignition chamber with a starting slug of aniline furfuryl alcohol separated from the JP-X by a burstable diaphragm. Nitric acid and aniline furfuryl react immediately and violently.

Unlike other surface to air missiles, the Bomarc has no single launch-to-target guidance and firing command system. It is remotely launched by a SAGE Direction Center, such as the one at Kingston, N. Y., and vectored toward the target much like a manned interceptor. The self-contained terminal guidance target seeker controls the missile only on the final run on the target.

Labeled an unmanned interceptor, the cost reduction made by eliminating a pilot and his controls along with associated landing gear and take-off and landing mechanisms, enables the Bomarc to be delivered to its base less warhead for $400,000. This is less than 10% of the price of a manned fighter capable of surpassing Bomarc's Mach 2.75 cruise performance.

The Bomarc was developed by Boeing and the Michigan Aeronautical Research Center, whose initials make up the designation BOMARC. Timing of the research program was perfect for mating it to the SAGE guidance system, the heart of which is the IBM AN/FSQ-7 computer.

Bomarc is currently being assigned to bases throughout the United States and Canada and is expected to become operational by the first of the year.

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ON THE COVER

Q-2C Firebee, newest version of the nation's number one free-flying jet target, recently claimed a new altitude record. Jet-powered Firebee reached 59,800 feet, Mach .96 speed.

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Sharp new eye for navigation

SHARPEST new "eye" for flight is the Ryan C-W Doppler navigator. Based on the advanced development of continuous-wave radar, this system of electronics "intelligence" has been pioneered by Ryan and the U.S. Navy for navigation at all speeds. It tells pilots how to fly to any spot on the globe, with speed and precision, and lets them know exactly where they are at all times.

With the Ryan navigator, military aircraft and jetliners can fly a new "electronic skyway" which provides precise separation between planes and conserves time and fuel. And, because RYANAV systems work right down to ground and sea levels, these advantages accrue at take-off, climb-out, descent and landings, as well as enroute.

The Navy has selected RYANAV for installation in six major types of naval aircraft. They are already in squadron use in the Navy's first all-weather anti-submarine helicopters and are being installed in Army aircraft and helicopters, for low-level "nap of the earth" operations.

Reasons for such wide and versatile use are found in the unique features of RYANAV systems: They are the lightest, simplest, most reliable, most compact of their type. They are setting new standards of accuracy, freedom from adjustment, and ease of maintenance... opening new areas of navigational, guidance, and orientation applications. Ryan electronics engineering assistance is available upon request, to those who wish to explore these areas.

Ryan's rapid growth in electronics is creating new opportunities for engineers and technicians

Ryan REPORTER

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SPACE MIRROR

VOL. 21, NO. 2

T GREGORY

TREE-TOP TARGET

Firebees fly "down-on-the-deck" in ground-to-air weapons training

REMARKABLE remote radar control ability at low altitudes has been demonstrated in ground-launching tests of Ryan Firebee jet targets at the U. S. Army's White Sands Missile Range, New Mexico.

Army Firebees have flown as low as 700 feet altitude, to a range of 27 miles from the remote ground controller, in unprecedented low level missions which point up the operational capabilities of this jet target.

An unusually high level of reliability for the new ground launching technique was achieved in three months of exhaustive testing at the White Sands Missile Range. During this period, the Firebee was ground launched 20 times. In addition to proving the Firebee's low altitude capabilities, the jet target provided effective evaluation of ground-to-air missile systems also under test on the White Sands Range.

Ryan engineers pointed out that ground "clutter", resulting from electro-magnetic conditions associated with the earth's surface, is a formidable interference problem in radar control at low altitudes — a problem which becomes aggravated with increasing distance from the control station.

Infrared flares on wingtip save Firebee for more missions by diverting heat-seeking Redeyes (opposite) from engine exhaust.

The performance of the Army Firebees has shown the feasibility of using it as a low altitude target to test and evaluate Army missile systems designed to combat low-flying aircraft.

Low-level control of a target missile presents a number of problems. With high frequency command systems, remote control of the target is limited to line-of-sight. This can be extended by using air-to-air control, relay stations, or programmed flight.

Air-to-air control has some limitations, even though it is immediately available. Live missiles can't be used, since it would be unfortunate if the missile were to lock onto the control airplane.

Tracking range beyond radar line-of-sight can be accomplished by establishing relay stations along the course. In this way, commands can be relayed to the target, and flight performance can be relayed back to the controller's plotting board.

Another serious problem in low-level flight is the degree of training and efficiency of the control operator, and the accuracy of information that he receives

(Continued on Next Page)

about the target's flight pattern.

Loss of altitude during turns, a normal operating characteristic of the Firebee, can be ignored at high altitudes. At low-level flight, ignoring this loss in terrain clearance could be disastrous. Low-level operators must be trained to execute "climbing turns" and, in addition, be extra vigilant in checking altitude information from the target. Small variations over mountainous terrain can quickly add up to an expended Firebee.

During the recent, exhaustive tests at White Sands, these problems were successfully overcome. Twenty ground-launched flights were made with the Firebee in three months, showing the feasibility of using it as a low-altitude target to test the new ground-to-air weapon systems. Ground launching techniques also give these controlled-flying jet missiles a new operational dimension. Most Firebees in operation are currently being air-launched from Air Force B-26s and C-130s and from Navy JD-1Ds and P2Vs. The ability to launch from the ground will release the targets from dependence on launching aircraft.

An 81-foot rail launcher, designed by Ryan, has been used in the first phase of the testing program, conducted under auspices of the Army Rocket and Guided Missile Agency, Redstone Arsenal. Firebees are rocketed into the air with the assistance of JATO (jet assist take-off) boosters, which provide an additional "kick" until the airborne Firebees roar away under their own jet engine power, guided by the remote control station on the ground.

In the second phase of the program, Firebees have been successfully launched from a near-zero length launcher, built by Fruehauf Trailer Company, at White Sands. In the near future all Ryan Firebees, including the advanced Q-2C version, will have ground launch capability.

Although the current program is devoted to low-level capability, the Firebee is also capable of testing high altitude weapon systems. A ground-launched Firebee can climb to 15,000 feet in less than 3 minutes, allowing sufficient additional time for flight on the target mission. In one of the early ground launch tests, a Firebee quickly attained the prescribed mission altitude of 27,000 feet, where it flew under remote control for thirty-two and one-half minutes before parachute recovery was commanded. Ground launching also cuts launch costs, increases reliability and eliminates the time needed to acquire the target by tracking radar.

Firebee flashes out from ground launching site at White Sands to begin low-level mission for new ground-to-air weapons evaluation.

Small explosive charge, followed by water geyser, signals forming of "space age" metals in any size or shape by Ryan engineers.

ARMY EXPLORES HIGH-ENERGY FORMING

Ryan Aeronautical Company engineers will conduct experiments in forming tough "space age" metals into complex shapes applicable to missile fabrication under a contract to the U. S. Army Arsenal at Watertown Massachusetts, T. Claude Ryan, company president, announced recently.

The Watertown Arsenal Laboratory is, among other things, a metals research and development facility, supplying technical information to the U. S. Army Ordnance Corps. Working with an Army physical metallurgist, Ryan engineers will perform extensive tests in explosive forming

(Continued on Page 19)

Twin turbines of the Navy's HSS-2 Sikorsky high-speed helicopter lift it aff the water during flight trials at Stratford, Conn.

NAVIGATORS FOR THE NAVY

Bureau of Naval Weapons awards $6 million for Ryanav* systems.

Part and parcel of Ryanav system light weight and compactness is the extensive use of photo-etched circuits. A Ryan technician checks a print prior to photographing and reduction.

A CONTRACT for $5,914,000 has been awarded to Ryan Electronics division of Ryan by the Bureau of Naval Weapons. The contract covers initial procurement of AN/APN-130 doppler radar navigation sets, spares, support equipment, and engineering support items.

The Ryan navigation sets will be supplied for use in the Navy's latest rotary wing anti-submarine aircraft, including Sikorsky HSS-2 amphibious helicopters and Kaman HU2K-1 helicopters.

Both helicopters are turbine-powered high-speed aircraft. The HSS-2 has twin General Electric T-58-6s, developed by the Navy specifically for helicopter use. The engines are rated at approximately 1050 shaft horsepower and are mounted side by side above the fuselage. The HSS-2 is also the world's largest amphibious helicopter.

The Kaman HU2K-1 is also powered by the GE T-58-6 turbine engine. HU2K-1 was ordered by the Navy as the winner of a design competition in 1956 which called

* Trademark

for performance characteristics exceeding any then-existing helicopter.

Speed and other performance data of both helicopters are classified.

One of the most important components aboard both helicopters will be Ryan's APN-130 C-W doppler navigation set. This unit is designed primarily as an all-weather ground velocity indicator for helicopters and airships, and other aircraft having hovering and negative speed capabilities. It operates on FCC interference-free authorized frequency of 13,300 megacycles and provides accurate navigational data at altitudes up to 10,000 feet.

The APN-130 automatically and continuously measures and displays heading speed, drift speed, and vertical speed without the aid of ground stations, wind estimates on true airspeed data. The set also provides outputs for tie-in with helicopter ASE (automatic stabilization equipment), ground position computing and indicating equipment, and course and distance computing and indicating equipment.

This equipment is completely self-contained and functions reliably anywhere in the world and under any weather condition. It operates from "zero" speed to plus or minus 150 knots and is designed to detect fore and aft motion (heading speed), left and right motion (drift speed), and up-down motion (vertical speed), enabling helicopters to maintain sustained precision hovering even under conditions of zero visibility. When tied in with automatic stabilization equipment and an altimeter, the heli-

(Continued on Page 19)

Ryanav reliability comes from carefully controlled, laboratory-clean production facilities. Clear Plexiglas shields on assembly lines protect precision parts from dust, moisture.

Another high-speed, turbine-powered sub-killer, the Kaman HU2K-1, is Ryanav-equipped for automatic hovering, all-weather flight.

Ryan Aerolab space probe rocket soars far out from earth in support of man's continuing search into the ages-old secrets of space.

RYAN: SIGNPOSTS FO

IN the very near future, man will take his first groping, stumbling steps into space. To firm these timid steps into free-swinging strides, man will need information about the new realm he is invading.

Space probes and sounding rockets assembled by Ryan's Aerolab Development Company are now gathering that information.

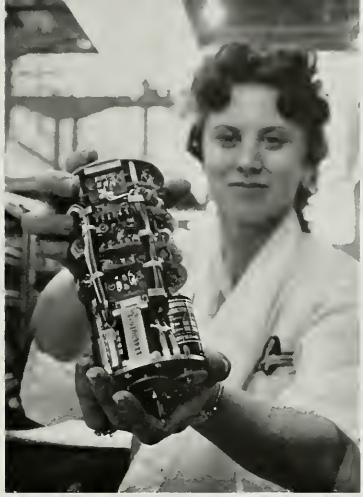
As man wanders farther into the deep recesses of the universe, he will require precise guidance.

Today, Ryan is designing space-age navigation systems.

The machines which man must use in space will be built of new metals, shaped with new methods, and built with new techniques.

Ryan is now using tomorrow's metals to shape and fasten together to-

Ryan chemists evaluate today the plastics which will be in the structure of the high-speed aircraft of tomorrow.



Navigation in a neat package comes from careful design, and miniaturization of parts.

Ryan Wrap* offers the high strength and light weight needed in space age flight.

* Trademark

Flight in the future will depend on high-strength, light-weight, heat-resistant metals, such as this titanium under test at Ryon.

SPACE

morrow's metals.

Ryan is a specialist in tomorrow.

From Ryan Aerolab comes the space probes and sounding rockets that tell us of the extent of the Van Allen radiation belt which surrounds our

(Continued on Next Page)

Perfect parabolas for radar antennas are formed in split secands in this highly-palished die at Ryan's high-energy forming site.

earth, which informed us that the upper atmosphere was much denser than supposed, which measured solar radiations in the ultraviolet and X-ray regions of the spectrum, and which continue to gather the bits and shreds of information we must have.

At the Ryan electronics division, scientists and engineers study the problems of electronics with which the age of space has confronted us. Instruments for space navigation are evolved; integrated systems to enable space vehicles to make "soft" lunar landings are developed; and entire systems are shrunk until they could fit into "Tom Thumb's thimble."

Even more pressing present-day problems must be dealt with. The exigencies of the Cold War demand highly sophisticated electronic devices. The threat that enemy satellites may be used to deliver weapons demands the development of anti-satellite weapons, which will require self-contained guidance system. Our own satellites and weapons must be fitted with electronic

Ryanav* navigation systems will help man make "soft" lunar landings, provide him with signposts through trackless space.

* **Trademark**

countermeasure devices. Communication and radar jamming, radar deception and radar destruction will be part of tomorrow's techniques of war.

Tomorrow's electronics can be turned to peaceful use, too. Navigation satellites, by which the position of a ship at sea can be easily and exactly determined, will be in use. Other satellites, which will act as reflectors or repeaters, will make global radio and television coverage a reality.

In the earth's atmosphere, the supersonic commercial aircraft of to-

(Continued on Page 21)

An aircraft which anticipated tomorrow was the Ryan Vertijet, world's first jet-powered vertical take-off airplane.

SENTINELS

Gravity propulsion would put miss

by Martin N. Kaplan, Senior Research E

N SPACE

ecting patrol in space

Ryan Electronics Division

"Eternal vigilance is the price of liberty"
John P. Curran

THE threat of massive retaliation in the event of nuclear attack is not a sufficiently strong military posture for this country. There always is the possibility that a great part of this country would suffer near-annihilation through accident or through madness. What is desperately needed is a means to intercept intercontinental ballistic missiles in mid-flight, a feat which cannot be done by present-day missiles, both because of the limitations inherent in the missiles themselves, and because of the lack of time. We will not be warned until the missile is well on its way.

We require a fleet of manned satellites, constantly in orbit and on watch for the lift-off of enemy missiles, ready to intercept and destroy them in mid-flight. Present-day chemically-fueled rockets do not possess the duration for such a mission. Nuclear, ion, and plasma rockets must be ruled out because of weight or because of very low initial velocities.

A new system of propulsion, which would permit very high speeds coupled with high initial velocities and long flight duration, is under study at Ryan. The company is engaged in a basic research program in force fields, which could lead to the needed propulsion.

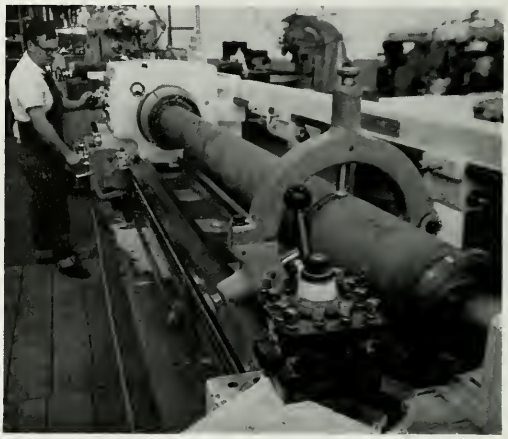
Two general approaches to the

(Continued on Page 20)

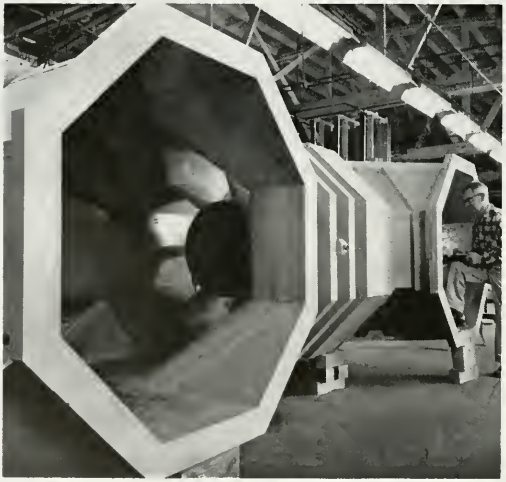
RYAN RECEIVES $8 MILLION

ROCKET CHAMBERS FOR THE "VIPER"

Ryan has begun production of "Viper" rocket chambers for Grand Central Rocket Company of Redlands, California, the nation's fourth largest manufacturer of solid propellants for rockets. Delivery of the rocket chambers, to be manufactured at Ryan's San Diego plant, began in April. The rocket assemblies are 105 inches long and six and one-half inches in diameter. After the rockets are delivered from Ryan, Grand Central will load them with specially developed solid propellants. The steel alloy rockets are used to propel high-speed test sleds, ranging up to the Mach 2 category. These high-speed vehicles are utilized at various bases as research tools to check human reactions and to aid in the development of such equipment as parachutes and low level ejection apparatus. In addition, aerodynamic shapes can be checked on such devices. Ryan has had many years of experience in rocket production, having produced U.S. Army "Corporal" rocket motors for several years.



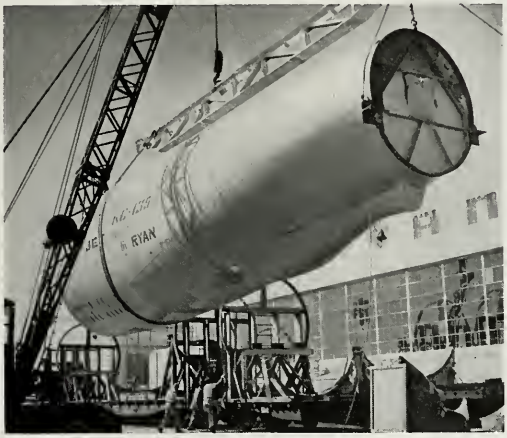
RESEARCH WIND TUNNEL FOR INDIA



Engineering students at the University of Roorkee in Bombay, India, will soon be conducting wind tunnel tests with a prefabricated subsonic wind tunnel from the Aerolab Development Company, Pasadena, a subsidiary of Ryan. The wind tunnel was shipped from Aerolab to Bombay, India, under the auspices of the Scientific Division of CARE, Inc. United States Information Agency headquarters in Washington, D.C., said the sending of such equipment to Indian universities is part of a State Department program financed by interest payments on the United States Wheat Loan to India in 1951. The unique "do-it-yourself" wind tunnel provides the engineering students with the added experience of fabricating and assembling parts of the tunnel after its arrival in India. All critical component parts, such as power sections, test section structures, vanes, lights and miscellaneous hardware are included in the Aerolab shipment. Engineering and assembly drawings and maintenance and operating manuals are also furnished to enable the students to complete construction of the tunnel.

N DIVERSIFIED CONTRACTS

TANKER AFT FUSELAGES FOR BOEING



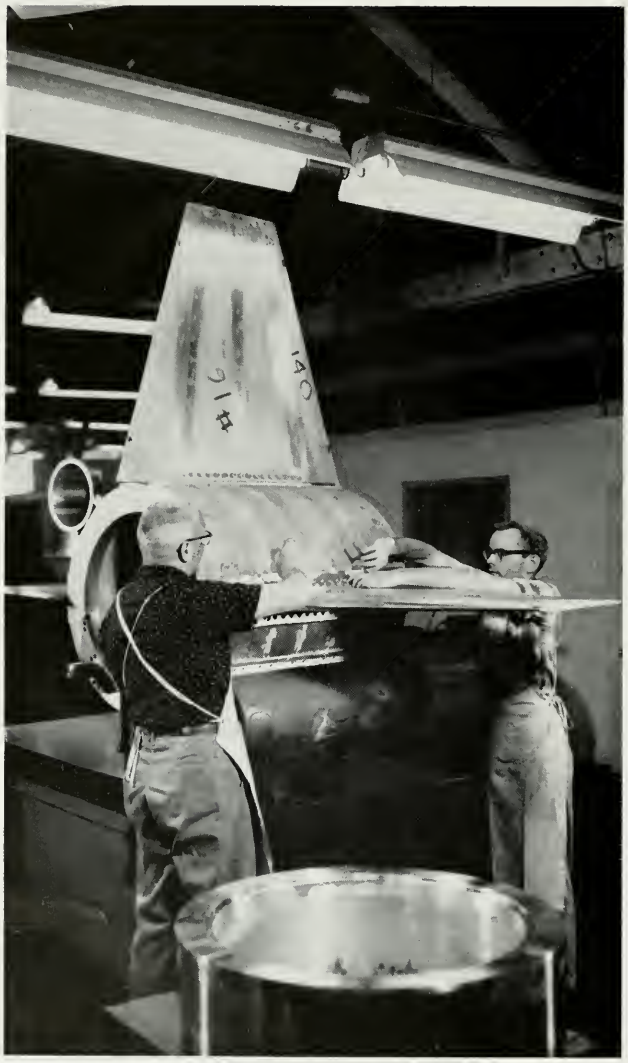
Ryan recently announced the award of a new $6 million contract for an additional quantity of fuselage sections for the Boeing KC-135 jet tanker-transport. The new contract assures production of the giant assemblies into late 1961. Ryan has delivered approximately 370 fuselage sections to Boeing's Renton, Washington, plant since assembly operations began in 1955 at Ryan's San Diego main plant. The 40-foot long, 3-ton units are the largest ever subcontracted on a volume production basis in the aircraft industry. They are shipped in specially designed holding fixtures on railroad flat cars to the Renton plant. The high-flying, high-speed KC-135 is the Air Force's chief "aerial gasoline station", utilized for mid-air refueling of jet bombers and fighters to extend their non-stop range for combat and patrol missions. This new order boosts total orders under the program to more than $75 million. Ryan also built nearly 900 sections for the KC-97, predecessor to the KC-135.

RYANAV* SETS FOR BRITISH ROYAL NAVY

The British Government has awarded Ryan Electronics a new contract for more than $1.5 million to purchase AN/APN-97A doppler navigation sets, spares and test equipment. This new order sends the total of British business on order to $2.5 million, including an earlier order for similar equipment. The automatic navigation equipment will be used in British Royal Navy anti-submarine warfare helicopters being produced by Westland Aircraft Ltd. of England. The AN/APN-97A is a self-contained airborne ground velocity indicator that detects up-down, fore-aft, and left-right movement, enabling helicopters to automatically achieve and maintain sustained precision hovering under zero-zero visibility conditions. By placing the helicopter control at the desired setting, the pilot can bring the aircraft to zero ground speed over a pre-selected spot. The sets are used extensively in United States Navy, Marine and Coast Guard helicopters to give them a heretofore unobtainable all-weather operational capability. Delivery of the units for the Royal Navy are scheduled to begin in May.

* Trademark

NERV SPEC



Shroud and fin assemblies for the three-motor first stage cluster of the Nuclear Emulsion Radiation Vehicle take shape at Aerolab. The first stage Sergeant with its two auxiliary Recruits will launch the multi-stage rocket.

Aerolab Argo D-8 rocket to boost nuclear radiation measurement package into space

AEROLAB Argo D-8 Journeyman rockets, developed by Ryan's newly acquired subsidiary, Aerolab Development Company of Pasadena, will boost 125-pound General Electric instrumentation payloads, on the Pacific Missile Range, for a closer study of the lower Van Allen radiation belt this fall.

The Aerolab-General Electric payload combination, called a Nuclear Emulsion Radiation Vehicle (NERV), will allow more accurate design of manned and unmanned space vehicles after the studies, ranging from 150 to 1800 mile altitudes, have been completed.

In the NERV program, both Aerolab Development Company and General Electric are prime contractors to the NASA, which also produces the nuclear emulsion package.

The highly exacting research flights will be made from the Pt. Arguello launching site on the Pacific Missile range, the four-stage Argo D-8 boosting the payload to 1200 mile altitudes over a 1700 mile course. Trajectory of the vehicle will be south from Pt. Arguello along one of the lines of force of the earth's magnetic field.

Prompt recovery of the nose cone, by parachute and pick-up by Navy ships will require exacting computation and prediction work by Aerolab engineers, to plot precisely the ballistic trajectory and impact point of the payload.

The four-stage Argo D-8 consists of a three-motor first stage cluster of a

ALISTS

Sergeant and two auxiliary Recruit rockets, second and third stages of Lance rockets, and a fourth stage of an Alleghany Ballistic Laboratory X-248 rocket.

The first stage Sergeant and two auxiliary Recruits cluster will launch the multi-stage rocket. The Sergeant will separate from the vehicle at 35 seconds from ignition.

After coasting 2½ seconds, the second stage Lance will fire. The second stage will burn, then glide until a pressure switch in the chamber of the second stage Lance causes it to disconnect and fall away, triggering ignition of the third stage Lance.

The third stage will burn out and drop away from initial first stage ignition, as the fourth stage X-248 fires. The fourth stage will then sustain propulsion.

At fourth stage burn out, the vehicle will be traveling at the maximum velocity to be attained.

The NERV vehicle and the fourth stage to which it is attached will be spinning at from 600 to 720 rpm at burnout. This will insure that the vehicle will stabilize along its line of flight at burnout.

After it passes maximum altitude, the vehicle will have an essentially tail-first attitude to the ground. The nose cone will then be de-spun to less than 40 rpm. This lower rpm is required to prevent the nose cone from tumbling.

At first stage burn-out the vehicle will have reached 65,000 feet. At second stage burn-out, the Argo D-8 will have reached 92,000 feet. At third stage ignition the rocket will be rapidly leaving the earth's atmosphere at 130,000 feet altitude, and at third stage burn-out, engineers predict the vehicle will have reached 180,000 feet altitude.

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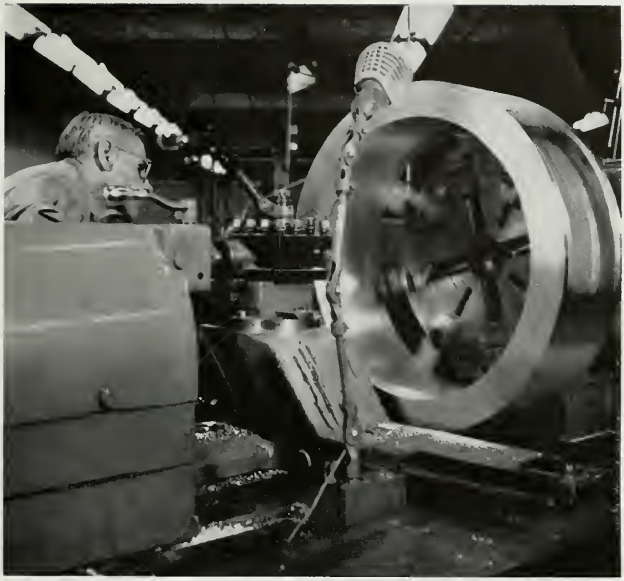
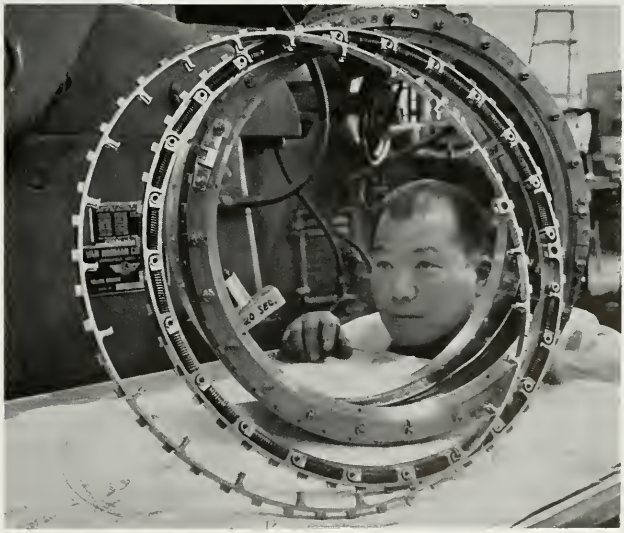


Huge lathes spin out intricately machined parts for the Aerolab Argo D-8 Journeyman which will boost General Electric's 125-pound payload to 1200 mile altitudes in NASA's nuclear radiation studies of the lower Van Allen belt.

With split second accuracy, these complex locking rings will separate the various stages as the Argo D-8 climbs into space. The NERV booster will be fired sauth from NASA's Pt. Arguello site on the Pacific Missile Range.



Hand sorting of mail will be a thing of the past under Post Office modernization program.

AEROLAB GETS POSTAL CONTRACT

A CONTRACT for engineering services and operations analysis in support of the $2 billion U.S. Post Office modernization program, initiated by Postmaster General Arthur Summerfield, has been awarded Aerolab Development Company of Pasadena, California, Lloyd R. Everingham, Director of the Ryan Space Laboratory and Aerolab Manager, announced this month.

Aerolab, an outstanding aerophysics and space development firm, is a recently acquired Ryan subsidiary. Everingham will direct the engineering group assigned to the Post Office project.

During the first year, under the initial $500,000 contract, Aerolab will make available 50 engineers, principally in Washington, D.C., to work with the Post Office Department's own engineering staff in integrating electronic mail-sorting machines, facsimile transmission, conveyor systems and other industrial automation techniques

(Continued on Next Page)

AEROLAB GETS POSTAL CONTRACT

(Continued from Page 16)

into the expanding, modernized mail system.

In addition to studies related to the actual handling of the mail, Aerolab engineers will be available to assist in the design for the Post Office's extensive new custom-tailored building program. Thousands of new structures are contemplated for construction across the country, for lease to the government, at the rate of four per day. All must be properly equipped and laid out for maximum efficiency. Studies will encompass optimum construction, mechanization and equipment standards, equipment arrangements, work flow and general criteria for the most efficient postal facilities.

Population increases and higher living standards have boosted mail volume to 66 billion pieces annually and the flood is increasing rapidly. Although the ideal objective, in which "a mail sack can be dumped into a conveyor and come out pouched for dispatch" may not be completely achieved, Post Office and private consulting engineers are joining forces to bring to the postal system the most advanced techniques and equipment which science and industry can devise.

One of the techniques which may appear in the near future is the use of mechanical mail sorters. Skilled operators will scan letters as they pass, and will type code letters on the envelopes with special machines. These code letters will duplicate the letter's city and state address in ink in which tiny magnetic filings are arranged in telltale patterns.

The letter will then pass through an electronic sorting machine which will rout the letters into the proper bins for further transmittal to the designated city.

Even more dramatic devices are being planned. One of the companies now assisting in the program has been assigned the task of producing a machine that will read printed or typed addresses and send instructions directly to the sorting machines, thus by-passing the human element completely. The device may be refined to the point where even handwritten addresses will be read.

To make the task easier for these electronic sorters, eventually addresses may be somewhat like today's method of dialing long-distance telephone numbers; thus 5-24-17 could send mail to the 17th postal zone in San Diego, California. To encourage standard size envelopes, which would simplify the

(Continued on Next Page)

Major Appointments At Aerolab

Appointments to three top posts at Aerolab Development Company, Ryan subsidiary in Pasadena, were, announced recently by Lloyd R. Everingham, Manager.

Forrest Warren, project engineer for 9 years on the Ryan Firebee jet target program, has been named Chief Engineer.

Frank Bolles, formerly of the Cornell University Aeronautical Laboratory, has been named Administrative Engineer.

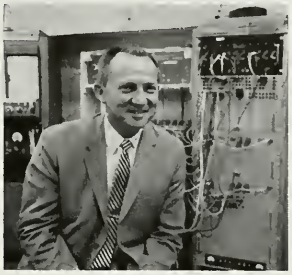
William Fischer, for the past 7 years associated with the contract and accounting departments at Ryan, has been appointed Financial Manager.

Warren joined the Ryan engineering staff 14 years ago. Besides his work on the Firebee through most of the life of that famed project to date, he was employed on various other engineering programs, including the Ryan Firebird, the Air Force's first publicly announced air-to-air missile, revealed in the 1940's. Warren attended San Diego State College and the University of Texas.

Fischer, a graduate of the University of Illinois, was affiliated with the First National Trust & Savings Banks and the Western Electric Company in San Diego prior to joining Ryan.

Bolles, a 1934 graduate of the U.S. Naval Academy, is a retired Commander with a record of 21 years' Naval service. He joined the Aerolab staff last month. As Administrative Engineer, he reports directly to Everingham.

Warren and Fischer, who have moved their families from San Diego to Pasadena, also report directly to Everingham.



FORREST WARREN
Chief Engineer

FRANK BOLLES
Administrative Engineer

WILLIAM FISCHER
Financial Manager

Ryan Firebees launched from Royal Canadian Air Force Lancaster, shown carrying two of the jet targets, were used in recent "Operation Blue Tar" in Canada, where U.S. Navy interceptors fired missiles at Firebees in snowstorms at night to demonstrate weapon system's all-weather, round-the-clock capability.

FIREBEES IN WINTER EXERCISE

All-weather round-the-clock capability of Ryan Firebee jet target missiles was demonstrated in night-time target missions conducted during winter storms at the Royal Canadian Air Force's station at Cold Lake, Alberta, it was disclosed following completion of the exercises.

All flights were conducted during snowstorms and in some cases heavy sleet, as Navy interceptors out of Pt. Mugu, Calif., fired Sparrow III missiles at the speedy KDA-4 type Firebees operated by the RCAF in "Operation Blue Tar."

Launched from RCAF Lancasters, the Firebees achieved a 100 per cent reliability on presentation as targets. Average flight time was 33 minutes, and the average altitude of the target missions was 7,000 feet.

"Operation Blue Tar" successfully tested the Navy's ability to operate its missile-firing interceptors at night under unfavorable weather conditions against distant aerial targets.

Navy planes can carry two to four Sparrow III's as a principal weapon in fleet air defense. Within seconds after launching, the 12-foot long, 350-pound Sparrow III attains a speed of 1500 miles an hour as it seeks out the elusive remote-controlled Firebee jet target.

Firings were performed in average temperatures ranging from 17 to 20 degrees F.

In snow flurry at freezing temperatures, Ryan Firebee jet target is retrieved by helicopter from frozen surface of Primrose Lake, recovery area 30 miles north of RCAF station at Cold Lake, Alberta, Canada.

AEROLAB GETS POSTAL CONTRACT

(Continued from Page 17)

sorter's task, the Post Office could offer users a discount.

Farther down the postal road is the "fax mail" plan. This method would transmit letters from coast to coast almost instantaneously by facsimile transmission, by using an electronic device which would "read" a letter, flash the image to a receiver by cable or radio, and then reproduce it on paper.

In conjunction with these plans to modernize and mechanize the operations inside the Post Office are plans to modernize the buildings themselves since the older buildings are poorly suited to mechanization. One new post office is the $15.5 million building now rising in Providence, R.I. This custom-tailored unit, dubbed Project Turnkey, will be a long, one-story structure, without columns that interfere with placement of machinery. The new post office will be able to handle about 2 million pieces of mail a day, nearly 50% more than the present Providence facility can handle.

The new post office will incorporate one of the newer methods of sorting, now in use at the Washington, D.C. post office. This machine moves cancelled letters, one by one, past operators seated at key boards. The operators strike keys causing the letters to drop into bins marked for 300 destination cities. The machine is faster than hand sorting by some 27%, and gains an additional percentage in that hand-sorters can handle no more than 84 destinations.

As fast as these machines are, they are still limited by the operator's reading speed. Once magnetic ink coding is introduced, sorting speed will be limited only by the machine's own velocity.

As far-reaching and extensive as the program toward complete mechanization is, the ultimate will probably never be reached. "How," asks Wade Plummer, "do you 'machine' a box of baby chicks?"

NERV SPECIALISTS

(Continued from Page 15)

At fourth stage burn-out, the vehicle will have reached an altitude of 600,000 feet. Aerolab engineers compute the NERV vehicle's apogee at approximately 1200 miles.

The ballistically guided vehicle will have fins on the first three stages to control the spin rate of the vehicle so that the fourth stage will be spin-stabilized at third stage breakaway.

The General Electric NERV payload is designed to provide a visual record of the characteristics of both low and high energy ionization particles above the atmosphere by allowing the particles to strike an exposed nuclear emulsion in the nose cone.

Conditions at various altitudes will be obtained by rotating the emulsion behind a small shutter, so that only a small portion of the emulsion will be exposed at each height.

A cylindrical disk of nuclear emulsion, three inches in diameter and one-half inch thick, will be fully extended from the nose cone at approximately 150 miles altitude during the vehicle ascent. The emulsion will continue to be exposed until the NERV vehicle is within 200 miles of the ground on the way down.

At 120 miles altitude, the emulsion package will be telescoped forward out of the forward end of the nose cone. A small electric motor in the rear of the package will rotate the unit 360 degrees during the flight so that all the film will pass by the shutter.

On re-entry, an extended skirt-type parachute will be deployed at 40,000 feet, with an opening shock of 40 g's or less, to slow the nose cone to a descent of 50 feet per second when it hits the water. This will cause a shock loading of 60 g's.

Navy aircraft and ships will stand by to pick up the nose cone which will be equipped with a number of location and spotting devices.

Smaller rockets and/or balloons will be fired, prior to the NERV launch, to obtain wind data and other variables that will affect the vehicle's trajectory. The data will be fed into a computer, and corrections made on the NERV launcher will allow a precise prediction of the nose cone impact area.

NAVIGATORS FOR NAVY

(Continued from Page 5)

copter pilot can command a fully automatic maneuver from normal cruise conditions through transitions in both speed and altitude to a hover.

Virtual elimination of "memory-mode" operation over extremely smooth seas has been a major objective in the design of the APN-130. Navigational accuracy permits errors of less than two per cent to be achieved at altitudes up to 10,000 feet.

The set features a unique fixed-antenna system that has no moving parts and requires no adjustments, thus assuring virtually 100 per cent reliability. Plug-in modular construction of sub-assemblies simplifies maintenance. The set embodies the most advanced transistorization and etched wiring techniques. It has a direct-to-audio doppler detection system which requires no I-F amplifiers or AFC. Also included is a frequency tracker to provide improved accuracy for navigational purposes.

The APN-130 can be tied in with a number of associated equipments such as; helicopter automatic stabilization, local area navigational equipment, ground position computers (North-South, East-West miles traveled), course and distance computers and indicators, heading reference systems, and ground speed drift angle indicators. It can also include plotting boards for visual display or present position and heading, automatic or manual track recording, search pattern programming, and station keeping.

HIGH ENERGY FORMING

(Continued from Page 3)

various standard and exotic metals and studying the metals' metallurgical characteristics. In the tests, aluminum alloys, titanium alloys, stainless steel and other steel alloys will be formed in various shapes and thicknesses. The technical information derived from these studies will be used in the fabrication of weaponry.

Ryan, with two years' background in explosive forming research and development, has formed more than 200 different intricate parts with the new process. More than 35 tough alloys have been instantly formed into hemispheres, bell shapes, corrugations, deep draws, embossments, and many other shapes in the traditionally tough metals with the process. In the process, a metal part is placed in a die and the assembly is lowered into a pit which is filled with water. A charge of explosive is positioned within the die. When detonated, the explosion forces the water against the part, into the shape of the die. The metal is forced into the die's shape at speeds of 200 to 500 feet per second compared with the only one to five feet per second in ordinary methods.

Official Named At Aerolab Plant

James H. Hedberg, a member of the engineering and sales staff of the Aerolab Development Company since July 1958, has been named Director Customer Relations of Aerolab, Ryan's recently acquired wholly owned subsidiary in Pasadena.

J. H. Hedberg

Experienced in mechanical engineering, missile guidance and propulsion, technical sales and administration, Hedberg previously was with Firestone Tire and Rubber Company—builder of the Corporal — as a Design Engineer, Project Engineer, Supervisor of the Propulsion group and Senior Staff Engineer. He is a graduate of the University of Minnesota.

During redesign of the Corporal engine, Hedberg was responsible for development of the only known ground simulation of in-flight drag effects upon liquid rocket propulsion system shut-off transients and post shut-off phenomena.

Ryan has been building Corporal rocket engine cases for Firestone for several years. The 100-mile range guided missile is now deployed with U.S. Army Forces in Europe and with NATO ground forces. It can be equipped with either nuclear or conventional warheads.

SENTINELS IN SPACE

(Continued from Page 11)

problem look promising. One is known as "unified field theory." The other might be called a "quantum mechanical theory of free space". The latter is derived from a quantized model and has led to successful experiments. Additional experiments are being assembled now. These are expected to precede a more comprehensive research program which, if successful, will yield one of two results, either restricted or general.

A restricted result, which might be termed antigravitation, would permit an acceleration which could be directed only toward, or away from, a second body. A general result would permit a reaction against free space. Either would be a revolution in propulsion.

Ryan anticipates a general result. Only one major break-through is needed — the development of a means capable of converting potential energy (perhaps nuclear) to kinetic energy in the form of rectilinear momentum without expelling mass. Such a breakthrough seems possible, especially after we better understand the mechanism by which matter is converted to energy.

The thrusts generated by such engines would be directly proportional to their energy conversion rates. Neglecting energy losses, the vehicle's rate of change of momentum would be limited only by its peak energy conversion rate.

These energy conversion rates could be safely employed to result in space accelerations of 100 g or more—not so fantastic in the light of recent experiments. Ultracentrifuge tests have produced reactions against space of nearly half a million g (centrifugal force can be considered the reaction between mass and space that results when a moving body is deviated from motion along a straight line). So it would seem that once the requirements for rectilinear reactions against space have been discovered, 100 to 1,000-g propulsion should be attainable. Townsend Brown, an American who has been researching gravitation for over 30 years, claims to have achieved "electrogravitic" rectilinear reactions which resulted in weight losses as high as 30 per cent. The author has observed two different experiments in which torque was generated without apparent system countertorque.

A complete cycle of acceleration and deceleration at 100 g would take a vehicle from earth's surface to an altitude of 1,000 miles in 80.8 seconds, neglecting atmospheric drag.

While such acceleration might be safe for the vehicle's structure, it would be disastrous for its occupants and their delicate scientific apparatus. But if the same principle used to accelerate the vehicle to 100 g was employed to provide a g-controlled environment for its occupants, then their environment could be regulated by using accelerometer sensors to attain a normal one-g acceleration toward the floor of the vehicle and essentially zero-g acceleration in orthogonal directions. In other words, their environment could be a near-perfect simulation of rest conditions on earth, except for the slight sensation caused by regulatory errors along the pitch and roll axes.

One defense system such propulsion would make possible would involve six "stacked" counterorbiting fleets of 24 inhabited ICBM detection-pursuit vehicles per orbit and counterorbit. The vehicles in each orbit (12 in each direction) would be spaced about 2,075 miles apart. Each fleet could patrol continuously an area of at least 2,000 miles wide extending completely around the world. One hundred forty-four patrol vehicles maintained in space at all times would give continuous early warning coverage over the entire surface of the earth.

If continually orbiting vehicles could not be employed, they could be deployed in a hovering position to form a space blockade around any hostile power. This would be more costly to maintain per vehicle than the orbiting system, as energy would have to be expended continuously to maintain a hover. However, the number of units in a hovering fleet would be considerably fewer than in an orbiting fleet.

As a by-product of the early warning systems, closed communication links could be maintained. Separated by only 2,075 miles, the tandem vehicles of each orbit, as well as the vehicles in a hovering blockade, would be within line-of-sight of each other and thus could act as repeaters for information originating in any one of them or at any station on earth's surface in communication with any one of them.

These patrol vehicles could be designed to accommodate a crew for an

(Continued on Next Page)

ABOUT THE AUTHOR

Martin Nathan Kaplan, a senior research engineer at Ryan Electronics Division, is one of the nation's most active researchers in the field of gravity. He began these studies in 1934 and has since conducted a continuing analysis of electricity, magnetism, and gravity in an attempt to better understand the relationship of mass, energy, and space. He was educated at the University of Wisconsin and has taken numerous graduate courses in force fields at other universities.

Kaplan maintains a private laboratory for gravitational research, and designs and builds much of his own test equipment. He is credited with several inventions in the electrical and electronics fields. He has written a number of classified technical papers, and recently has been active in the adaptation of continuous wave doppler radar to soft lunar landings and other outer space applications.

The equation shown on the blackboard is the general solution for the radial acceleration of a point in space due to gravitating mass m, located at distance (r).

SENTINELS IN SPACE

(Continued from Page 20)

orbital cruise lasting two weeks or more. They would have pursuit capability and could travel from earth to orbit and return with ease. They would encounter no re-entry problem. They would be able to rendezvous with, and relieve from duty, vehicles which had completed their tours in orbit. With a 100-g propulsion capability, one could be sent up from the ground to intercept and destroy in 200 seconds a missile 1,000 miles up traveling at 12,000 miles per hour. It would have plenty of time, considering that an intercontinental flight of a ballistic missile requires at least 30 minutes. Bases for such interceptors could be dispersed at will since the vehicle would require no runway, and, in fact, could be based on either land or water.

In addition to making a reliable defense against the ICBM possible, the effect on the world that such a breakthrough in propulsion technology would make is nearly beyond imagination. It would alter the daily lives of most of the world's inhabitants, for the number and magnitude of tasks which could be performed with such a capability seem almost limitless.

Obviously, a concerted basic research effort must precede the propulsion development. The potential applications make the research effort mandatory.

SIGNPOSTS FOR SPACE

(Continued from Page 9)

morrow will be guided by Ryan-conceived and developed navigation systems, based on the highly successful Ryanav doppler systems in use today.

In all of these things, Ryan will continue to contribute a leader's measure.

These electronic systems will be borne in vehicles made of metals that were metallurgical curiosities yesterday — metals that cannot be formed or joined together with the methods in use today.

Tomorrow's methods are in use today at Ryan. MiniWate, a design concept which uses very lightweight, heat-resistant metals to form very strong structures, is in production at Ryan. Ryan Wrap, a welding technique which joins together foil-gage layers of tough alloy, has been used to produce dozens of test rocket chambers for the Navy's Polaris guided missiles. These chambers have withstood hoop stresses of over 305,000 psi. High-energy forming, through which tough alloys are blasted into intricate and very precise shapes, is a production tool at Ryan.

This capability for tomorrow stems from a long history in meeting the demands of the future. Ryan designed, built and successfully flew the world's first jet-powered VTOL aircraft, the Ryan X-13 Vertijet. The company designed and successfully tested the Vertiplane, a deflected-slipstream propeller-driven VTOL airplane. Now under study is the Vertifan, a VTOL jet-propelled aircraft which rises horizontally from the thrust provided by huge ducted fans in the wings, and which will be capable of supersonic level flight. Not only are these aircraft important in themselves, but one facet of their design is highly important to successful space flight. All of them require the use of a highly sophisticated and completely reliable reaction control system.

Reaction control must be coupled with a parachute recovery system for the first generation of man-in-space capsules. Ryan-designed parachute systems have safely lowered to earth literally thousands of aircraft. The Ryan Firebee jet target missiles are recovered by parachute.

The Firebee target system is another proof of Ryan's capability in the space age. It is too late in wartime to find that a weapon is of no value, or that the men assigned to use it are not capable of using it. The Ryan Firebee, for years, has measured the worth of nearly every weapon the United States has, from .50-calibre machine gun fire to the Nike-Hercules. It has been the exclusive jet target at Air Force and Navy Weapons Meets. It has been fired at while flying in formation, at night, and in near-hurricane weather.

Special effort has been made to keep the Firebee compatible with new weapons as they appear and with special situations of the various using services. The Army is restricted as to launching facilities, so Ryan has developed a ground launching system for the Firebee. Higher aircraft speeds and more accurate missiles demanded targets with greater speeds. Now on operational status is the Firebee Q-2C, faster than its predecessor, the Q-2A, and with a higher altitude capability. On the drawing boards are even faster and higher-flying versions of the Firebee— birds that will operate at altitudes of over 60,000 feet and at speeds up to Mach 2.

What the space age demands of aeronautical science, Ryan will supply.

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ON THE COVER

Giant parabolic space mirror, designed to capture sun's rays on its aluminum reflecting surface, typifies Ryan's advanced research into solar energy applications.

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PRECISION-BUILT JET PODS FOR THE DC-8

PROBLEM—package the power of 16 locomotives and enclose it in a slim, streamlined pod.

SOLUTION—1) assign 100 power plant, aerodynamic, and aircraft structures engineers to work closely with Douglas design specialists, 2) put master-craftsmen through postgraduate training programs, 3) design and build the finest precision jigs and tools, 4) meet the most exacting quality standards ever created for air frame manufacture.

RESULT—gleaming pods that enclose ready-to-go jet power for Douglas' superb DC-8 Jetliner and supporting pylons also built by Ryan. These jet pods are an important contribution to the success of this greatest new airliner—created in the finest Douglas transport tradition.

Ryan is well-equipped to meet the challenges of precision production of DC-8 pods and pylons. For more than 33 years Ryan and Douglas have been doing business together. We are proud of this long association and the confidence which Douglas has placed in Ryan products and the excellence of their performance—for Ryan does Build Better.

RYAN REPORTER

Q-2C Launch 1
Anisotropic Satellites . . 4

WIRED BY PLAN

VOL. 21, NO. 3

Eagle-eyed accuracy of U. S. Army's anti-aircraft missile, the Nike-Hercules, is put to the test by ground-launched Firebees.

Q-2C MAKES GROUND LAUNCH DEBUT

By EMMETT SMALL
Technical Writer
Ryan San Diego Division

THE NEW MEXICO morning sun splashes over the orange Ryan Q-2C Firebee target missile resting on a four foot launcher. A group of Air Force officers confer with target system representatives from Ryan. Ron Reasoner, Ryan project engineer, informs the officer-in-charge that the pre-flight check is complete and that Ryan is ready. The Holloman Air Force Base range safety officer routinely clears the area, and signals approval for the ground launching.

The target's 1700-pound-thrust jet engine begins to whine. The launch control operator runs the engine up to launch rpm. Under the belly of this high performance Air Force target is attached a jet assist take-off bottle. The operator presses a button, the bottle fires, and from a cloud of smoke the eager Firebee breaks from restraining cable and leaps into flight at 190 knots. The JATO bottle falls away, and the target climbs quickly to 15,000 feet, a fluorescent speck against the blue of the southwestern sky.

Flight-ready Firebee awaits final word to go as Ryan engineers begin countdown from blockhouse at Holloman Air Force Base.

A slight smile appears on the sunburned face of Ed Sly, Ryan's supervisor of the ground launch program. Ed is piloting the target by radio remote control from the desert floor, having taken over the flight at launch from his console station, two miles from the launching site.

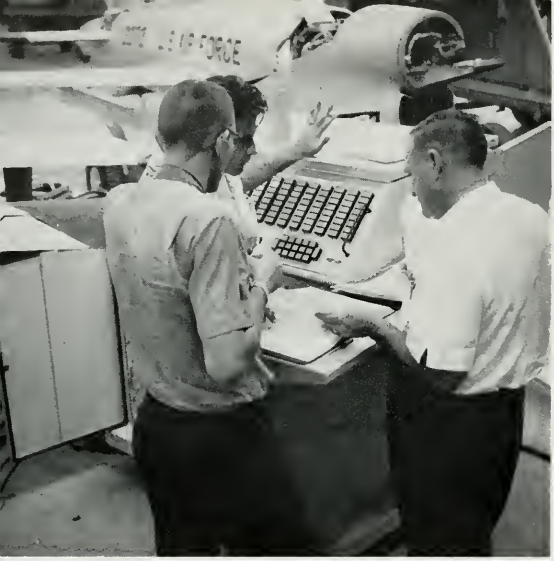
Five months of preparation led to this moment — a moment significant to taxpayers as well as to Air Force training requirements. For by ground launching the Q-2C. which was originally designed for air launching from an airplane, the cost of Air Force training is reduced, yet is increased in efficiency.

"By ground launching Firebees, the Air Force will cut launching cost, increase target reliability, and step up

Full-of-flight Firebee is flung away from four-foot ground launching rails by combined power of jet engine and jet assist bottle.

operational capability," according to W. A. Hite, Ryan program manager for the Q-2C.

The Firebee story is one of improvement and evolution over the years since 1947, leading to the high performance Q-2C. Active augmentation devices give the drone at 50,000 feet a radar appearance of a large size bomber. It can be equipped with countermeasure equipment and scoring provisions. Durability has been shown in the target's ability first of all to remain in flight as long as 1 hour and 36 minutes, then to be recovered by a special Ryan parachute system, and reflown, in one case as many as 25 times.



Complete system checkout of the Q-2C is start of ground launch program. Ryan-developed-and-built check-out console first checks own systems, then turns to diagnosis of Firebee.

Countdown about to start. Snug on the launching rails, Firebee points nose into the sky as engineers make last minute checks of JATO and missile. In seconds Firebee will be live target, testing ability of the nation's fastest interceptors.

Ryan Design Engineer John C. Graham, seated, uses telescope as he attaches JATO battle after system check-out. Bottle which drops away after Firebee is airborne, must be exactly aligned to prevent flight deviation. Firebee is ground launched.

But the latest evolution was not in the target itself but, as the recent New Mexico tests showed, in the method of its launching. Instead now of being protectively carried by an Air Force B-26 or a C-130 to a comfortable 15,000 feet and then released from mothering wings, the Firebee can quickly be ground launched. It rests simply on a Fruehauf launcher, ready at the scheduled moment for the boost which will fire it off by rocket motor.

The economic gains alone are striking: freedom from the costly restraining apron strings of a mother-plane; greater independence and control in scheduling test missions; ability to launch under almost any weather conditions.

The Ryan Firebee is the doughty aerial target missile which offers itself as a target to the deadliest attackers representing America's defensive might—Bomarc, Hawk, Talos, Nike Ajax, Nike Hercules. Ryan Firebees have become, for Air Force, Army, and Navy, the most realistic targets available for training to protect the country.

Firebee "attack" creates for Air Force pilots or Army missile ground crews the nearest thing to actual enemy offensive action; the bird's approach simulates war conditions under which various weapon systems are evaluated. Firebees thus provide for crews, planes and missiles the line training needed to key them for combat readiness.

Ground launching capability was not born overnight. Again it was a matter of evolution. Holloman ground launch tests of the Q-2C were preceded by testing at the White Sands Missile Range in 1959, where the Army conducted an extensive ground launch program. Today the Army ground launches Firebees for the missile firing program at White Sands, for the Army Rocket and Guided Missile Agency.

This experience aided Ryan in the recent Holloman program, designed to perfect ground launching of targets for improved training at Air Force bases throughout the U.S., Puerto Rico, and Okinawa where Firebees are used.

First air base to get ground launch equipment after Holloman will be Tyndall Air Force Base, Florida, where two Firebee ground launch installations will soon be made. Tyndall was the site of last year's annual Air Force weapons meet in which Firebees were used as the sole target to test the latest jet aircraft and their missile armament.

The 13-year-old history of the Ryan target system attests to its steady evolution as a useful, vital tool of the United States military forces for training in defense of this country. The demand for Firebees has been great. Over 1500 have been ordered by the Air Force, Army, Navy and Royal Canadian Air Force.

In a world of revolution, the secret of life still is evolution. In the sense of this definition the Ryan Firebee is very much alive. Splashed with orange sunshine, on its desert launch rails, it gave both Air Force and Ryan convincing demonstration of its continued versatility to measure up to new and demanding requirements.

Bottle and bird ready to go, ground launch nears its start, as Firebee is swung from ground handling cart and lifted onto the launching rails. Umbilical cords provide start control.

WORLD-WIDE TELEVISION WITH

ANISOTROPIC COMMUNICATION SATELLITES

by
MAURICE G. CHATELAIN
Senior Research Engineer, Preliminary Design
Ryan Electronics Division

The haze from Mr. Dillon's smoking six-shooter could spread 'round the world in the next few years if America follows up the isotropic configuration of Echo I with other communication satellites of anisotropic design.

Worldwide radio broadcasting, which includes television and FM radio, via orbiting artificial satellites appears to be the next great step in the art of communication if the anisotropic designs developed at Ryan Electronics prove as efficient in practice as they are in theory.

Television and FM broadcasting are limited to line-of-sight transmission. But Echo I proved that a radio beam can be bounced off a satellite, as dramatized by President Eisenhower's historic broadcast on Aug. 12.

It would be relatively simple to extend the limited range of TV-FM by reflecting the signal off a satellite and back to earth. With a series of orbiting satellites properly spaced so that any two consecutive vehicles were always within line of sight of each other, the signals could be bounced from satellite to satellite so that the listener could tune in the program of his choice anywhere in the world.

Echo's isotropic and spherical design made it a low efficiency communication satellite, however, for the simple reason that only one small part of the huge metalized sphere's convex surface can transmit the signal to any one receiver. Since television transmission needs at least 1,000 times more power than conventional radio, the trick is to design a satellite with a reflectivity at least 1,000 times greater than Echo.

This can be done with anisotropic, or irregular surfaces, rather than the isotropic, or spherical surface, of Echo. The remaining question seems to be which anisotropic design or designs will best do the job.

Advantages of relaying TV-FM signals by satellite are enormous. The frequency range, now 54 to 216 mc, could be increased to use the remaining portion of the VHF spectrum from 216 to 300 mc, plus UHF (300 to 3,000 mc) and microwave (3,000 to 30,000 mc). Since about six megacycles are necessary per channel, the higher we go on the spectrum, the more channels that are available per waveband. Too, a signal transmitted through space would meet none of the physical interference that now hampers broadcasting close to the earth's surface.

The first generation of communication satellites will be nonstabilized passive reflectors and it apparently is generally assumed that, for a given size or weight, an isotropic metalized

MULTI-CONE SATELLITE

CORNER REFLECTOR SATELLITE

CONVEX DODECAHEDRON SATELLITE

sphere such as Echo is the best solution. But for several reasons it now appears that anisotropic configurations should be better. Among those reasons:

1. A satellite is difficult to stabilize with respect to the earth, but it can be stabilized easily in relation to the earth's magnetic field so that, above any particular point on the earth, the satellite's polar axis always is oriented in the same direction.

Moreover, the maximum solid angle that can be subtended by the earth from a satellite is approximately 120 degrees, corresponding to an altitude of 600 miles. So, less than one-third of the satellite's surface can be used at the same time. But if the satellite attitude is known, the utilization of a directive reflector or antenna is possible.

2. Certain types of communication satellites do not have to be in operation all the time. By means of a storing and gating device similar to that used in meteoric communications, transmission of information could be limited to those times when the satellite's attitude is optimum.

3. Even if the satellite must operate all the time and has no stabilization, it still can be designed in such a way that most of the energy intercepted is backscattered to the earth, thus reducing the transmitting power required.

There are numerous types of communication satellites, both active and passive, that can be realized in spherical or polyhedral configurations with much higher efficiency than the iso-

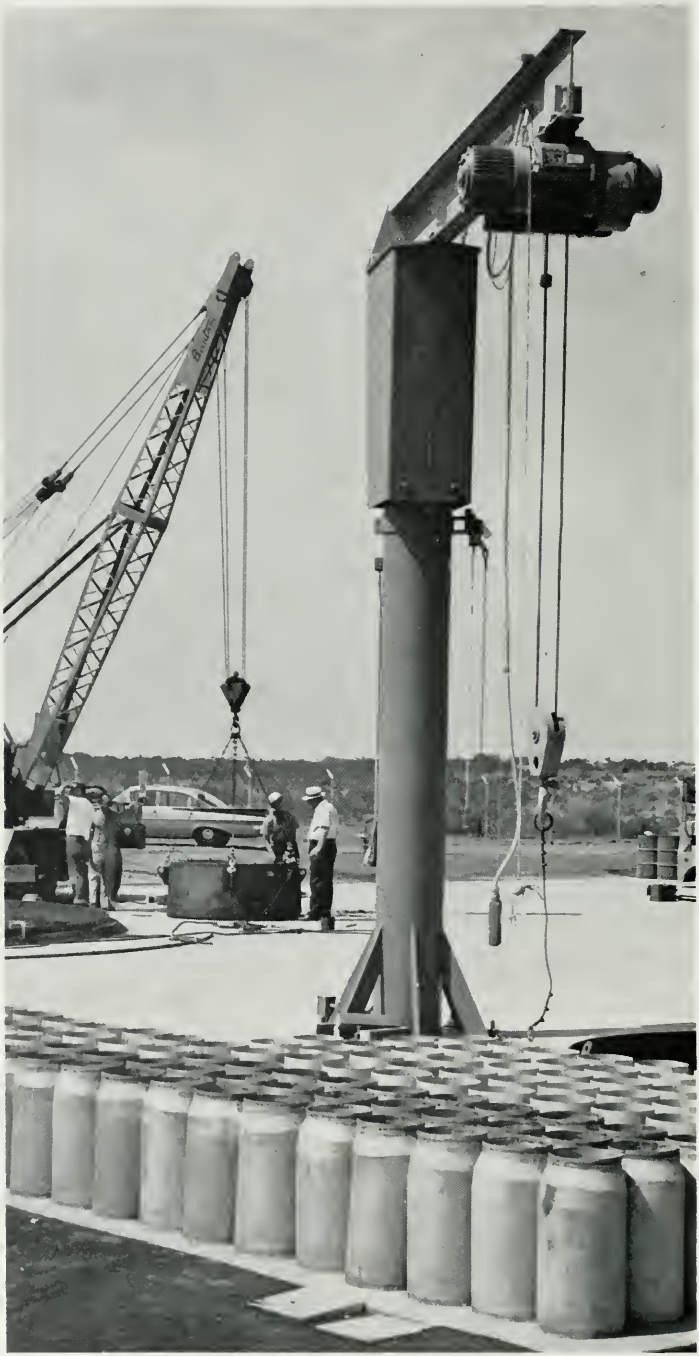
(Continued on Page 22)

RYAN-DESIGNED spiral antennas include one used for the Transit navigation satellite as shown in artist's conception above. Models hold great promise.

ICOSAHEXAHEDRON SATELLITE

MULTI-HELIX SATELLITE

DUAL POLARIZATION SATELLITE



CREATIVE SPLASH!

EXPLOSIVE

A quiet thud and a six-inch splash of water marked the opening of Ryan's new high energy forming production installation in San Diego.

The moment wasn't particularly dramatic but it was significant because it signaled the beginning of a new era of fabrication in the aircraft and missile industry: an era in which explosive forming is used for large scale production.

Prior to the opening of this new installation (believed to be the largest and best equipped in the country) Ryan manufacturing experts and explosives engineers spent two years perfecting explosive forming at an experimental facility at the company's main plant in San Diego. In this time they formed over 200 different types of parts while conducting exhaustive studies of materials, tooling, explosives and production standards. Opening of the new production installation in July

JET ENGINE tail pipes made of high strength steel for the Ryan Q-2C target missile are among production parts being processed at Ryan's new forming facility.

attests to the sureness with which these men have moved explosive forming and its advantages into the production line.

The new installation is on a 20-acre site in eastern San Diego, a few miles from the main plant. It will be used for volume production and development work on large components. The company's well-used experimental facility will still be maintained for manufacturing development programs.

An exponent of explosive forming large missile components, Ryan proved its point opening day. The part that was formed under that inaugural six-inch splash was a 54″ diameter skirt for the Polaris missile, marking the start of a production run for the Allegheny Ballistic Missile Agency.

These Polaris components are being formed in the largest of three water pits at the new forming site. The pits are 25, 10 and 5 feet in diameter, are 15, 10 and 8 feet deep, respectively, and have steel walls one inch thick.

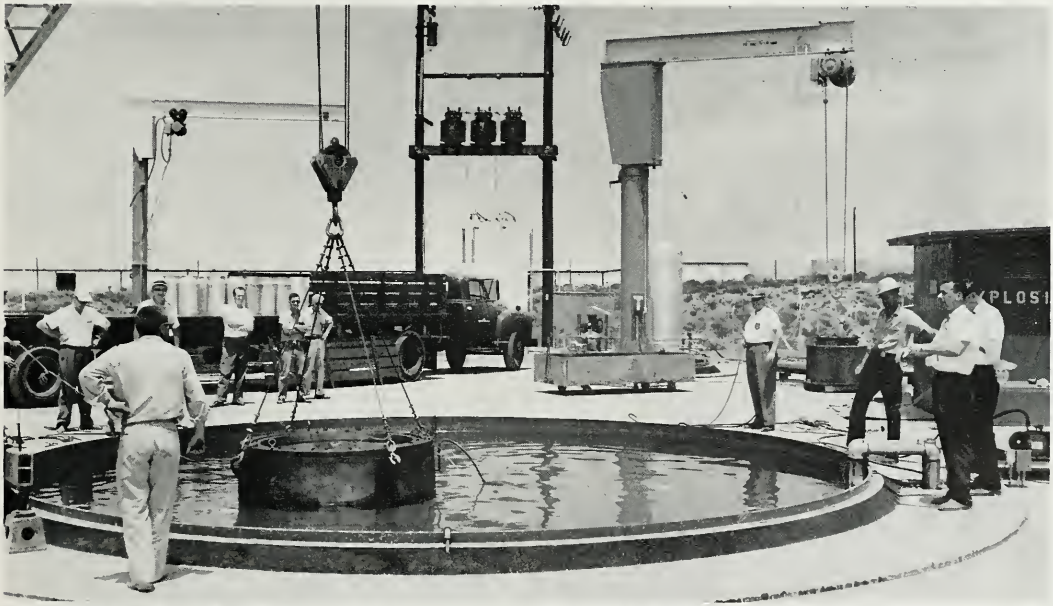
Dies are lowered into the water by overhead hoists. The explosive charge is submerged and detonated slightly above the die by a wire from an explosive control blockhouse 10 feet away. Normally the explosion is slight, rarely ever splashing water out of the pit. The water pressure forces the metal blank into the die, forming the part. It's quick and has many advantages over other forming methods, but it takes a lot of perfection and control.

The Polaris skirts are typical of the large parts, made of hard-to-form

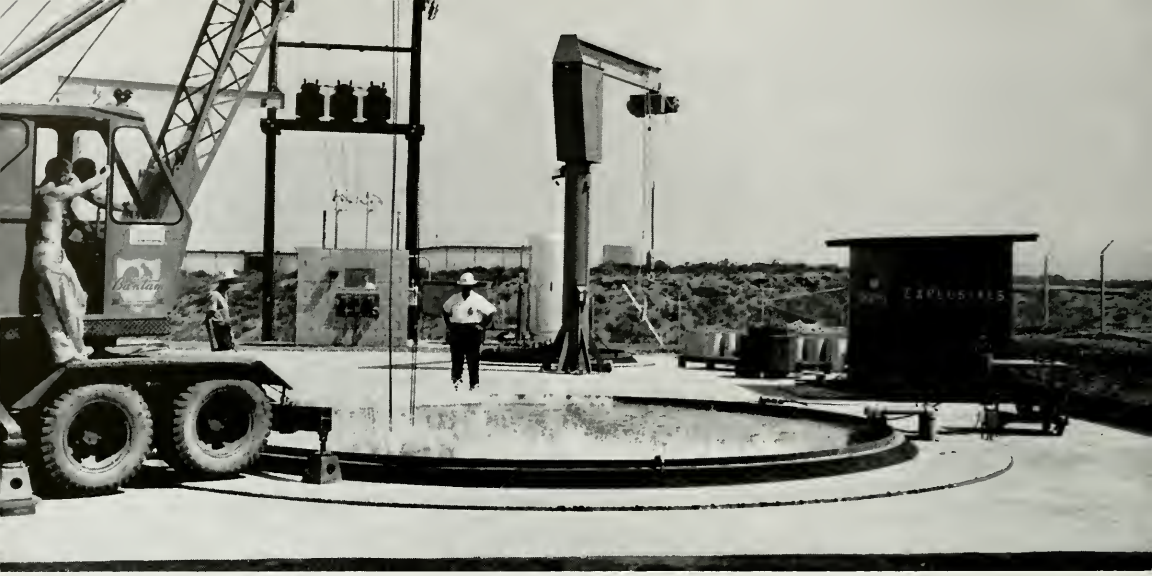
(Continued on Next Page)

FIRST STEP — Machinists insert a Polaris skirt into a single die of ductile iron.

FORMING FACILITY IN PRODUCTION



PREPARING CHARGE—Ryan technicians are shown lowering the ductile die into the pit for a shot at Kearny Mesa.



WHOOSH - - -BOOM! ! — At a given signal the charge is ignited and forming takes place within a split second. Ryan has produced Polaris compression skirts with minimum yield of 200,000 psi. Ryan installation has explosively formed over 200 different parts.

metals, that Ryan has found highly adaptable to the speed and force of explosive forming. Similar close tolerance jobs, the company is doing at the new site, include large aluminum hemispherical-shaped parts for the Army and double-curved sectors for a giant metal mirror, to be used in a solar concentrator. The mirror is being built for the Turbo Division of Sundstrand Corporation.

But Ryan's explosive forming work is not limited to missile and space components. Versatility is indicated at the new facility in volume production that includes:

Aluminum radar reflectors for aircraft antennas, built for the Dalmo-Victor Company. Being explosively formed by the hundreds, they are 30" long.

Aluminum nose cones for the Douglas DC-8 Jetliner, for which Ryan builds the engine pods and pylons and integrates the engine and its systems. This conical-shaped part was formerly made in five separate pieces; it is now explosively formed quickly as one part.

Angled jet engine tailpipes for Ryan's Firebee missiles, used by the military services as high performance targets. The tailpipe is formed out of 321 stainless, .035" thick.

Jet engine directional thrust ball joints for the tilting tailpipe of an advanced Navy plane. This unique component is made of L605, .063" thick. Two explosions in a ductile iron die from the 30" diameter part.

READY TO FIRE explosive charge from blockhouse is Engineer W. C. Wilson.

RYAN ENGINEERS check compression skirt — compound cone with a welded ring. After annealing in the furnace, a second shot brings it to final diameter and configuration.

THE word "impossible" took another shellacking with the disclosure that Ryan has in use a new method of resistance welding which permits sound joining of ultra-thin materials to thick.

The innovation is particularly suited to welding thin sheet metal, a few thousandths of an inch thick (up to .016″), to plates of considerable thickness—specifically, pieces whose thickness ratio exceeds 4 to 1.

With normal methods of resistance welding, the weld nugget usually forms within the thick material instead of equally at the interface of the two metals. The result is a weak, unsatisfactory bond.

Three Ryan welding engineers, John R. Fullerton, Laurence E. Leech, and Donald L. Heyser, tackled the problem, concluding that if two heads are better than one, certainly three heads are better yet. The new system they came up with produces a uniformly accurate and securely bonded structure. At the same time it is simple, safe and convenient to use.

The process employs three main factors: the application of a welding electrode under heavy unit pressure at the spot to be welded; shooting a heavy pulse of current to the electrode; and continuing the electrode contact pressure until the weld nugget is sufficiently cooled.

The new welding apparatus is comparatively simple. It consists of a power supply, timing mechanism, and a pressure system. The power source

(Continued on Next Page)

SPACE METAL SPOTWELDING

New Ryan technique welds tissue-thin to timber-thick

is connected to opposite ends of the primary winding of a transformer.

A timer connected to the power source is arranged to discharge through the primary winding of the welding transformer.

The secondary winding of the transformer is connected at one end to the welding electrode. The other end is either grounded to the welding table or attached to the thicker of the two materials being joined.

A wheel type electrode is ideally suited for use in the new welding process. Constantly pressurized by suitable means onto the work surface to hold the materials together at the point of weld, the wheel rolls along the surface of the thin material to produce a row of spaced spotwelds. Other types of pressure contact electrodes may be used, provided the pressure can be accurately controlled.

The timer employed must be able to control both power and pressure application precisely. Timing varies according to the material used and the type of welding being performed.

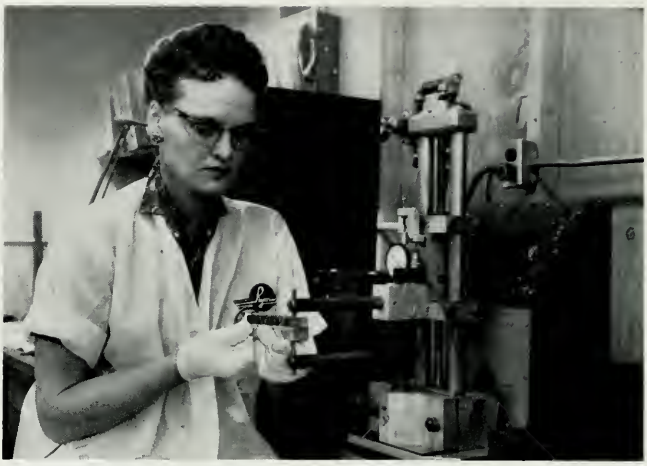
When the current is released through the primary winding, it causes a pulse of welding current to flow in the secondary winding.

The transformer then shoots a heavy current flow at low voltage through the welding electrode held on the work surface. A current of about 40,000 amperes at two volts has been satisfactorily used.

The electrode contact pressure also controls the interface resistance of the materials to a considerable extent, since the firmer the contact, the lower the resistance. Therefore, control of the electrode pressure is important.

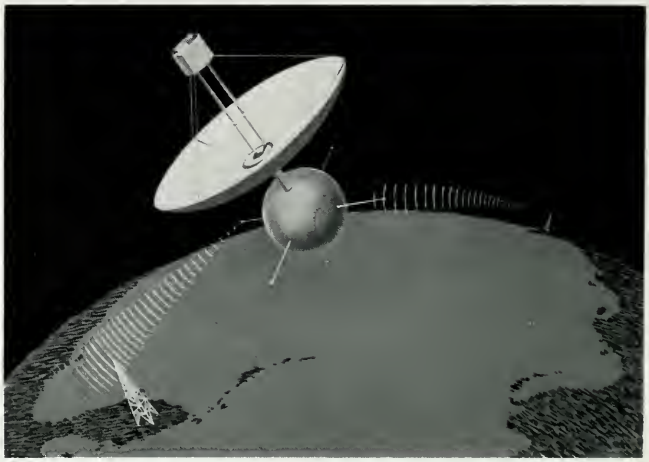
The critical factor in the weld is the surface resistance at the contacting faces of the metals. The electrode pressure is set in relation to the other factors controlling the interface resistance. Thus the interface resistance represents virtually the entire resistance to the welding current. Since the surface finish of thin sheet metal is generally smooth and carefully controlled, the

(Continued on Page 24)

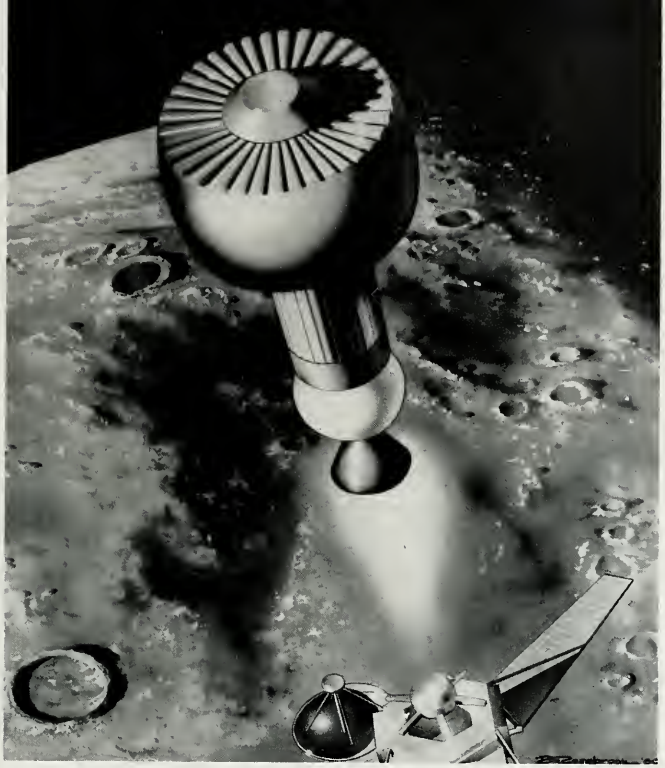


Featherweight joined to heavyweight by Ryan-built welding unit. Technician, above, holds strip of .001 to .010 inch welded to three-quarter inch block of type 321 stainless steel. Closeup of the strips are shown on page nine, 'Space Metal Spotwelding'.

Photo shows weld nugget between layers of stainless steel. Upper layer is .004 inch thick; lower layer is .064 inch thick.



New technique will be found in orbit with tomorrow's satellites, including this sun-powered communication satellite, which can offer global TV coverage.



HOW LUNAR CAPSULE WOULD SEPARATE FROM SPACECRAFT on command of Ryan Electronics altimeter 20 to 25 miles from moon's surface is envisioned in this artist's sketch. Rocket has been ignited to reduce impact velocity.

Ryan Electronics Will Develop

CAPSULE ALTIMETER FOR MOON LANDING

A contract to provide an altimeter for a lunar capsule has been awarded to Ryan Electronics. The award is one of two subcontracts announced by Aeronutronic Division of Ford Motor Company, Newport Beach, Calif., on its lunar capsule development program being carried out for the national Aeronautics and Space Administration.

In addition to the Ryan Electronics lunar capsule altimeter contract, Gerald J. Lynch, Aeronutronic general manager and vice president of Ford's Defense Products Group, announced award of a subcontract to Hercules Powder Company, Wilmington, Delaware, for a retrorocket.

Under contract to the Jet Propulsion Laboratory, Pasadena, Calif., Aeronutronic is building a 300-pound instrumented package which will be impacted on the moon within the next two years. It will be launched from a larger space-craft now being built at JPL as part of the Ranger program.

At a distance of about 20-25 miles from the surface of the moon, the lunar capsule will be detached on command by the Ryan Electronics altimeter and the retrorocket will slow the capsule's speed to impact at less than 300 miles an hour. The parent craft will be destroyed as it hits the moon at a speed of more than 5,000 miles an hour.

After crash-landing, the 300-pound instrument package, containing a seismometer, temperature-recording devices and other instruments, will radio data back to earth for as long as several months.

The altimeter to be provided by Ryan Electronics under the Aeronutronic subcontract will give the lunar capsule the "go" signal to separate from the Ranger spacecraft as it approaches the moon.

The altimeter, its antenna, and support structure will be mounted on the Ranger spacecraft and remain with it.

Ryan Electronics is a leader in continuous-wave Doppler navigation for both fixed and rotary wing military aircraft.

This Ryan Division also is involved in a number of space projects, including efforts toward solving such space

(Continued on Page 29)

RYAN FORMS TWO

Ryan Transdata Formed To Develop New Data Handling Processes For Industry, Military Management

Converting information by instantaneous processes into a form to aid industrial, governmental and military commanders in making rapid accurate decisions is a task which will be handled by Ryan Transdata, Inc., a recently formed subsidiary of Ryan Aeronautical Company.

Office automation techniques for private industry are applicable to data entry (indexing) and retrieval for such military services as the Strategic Air Command, where time is of supreme importance in making correct decisions; and to civilian and military libraries, where abstracts of all documents would be automatically available upon request.

Personnel working in air traffic control, military command control and surveillance, logistics control, supervisory monitoring and command control of space vehicles, and management control of varied functions, including inventory control, payroll data, work in progress, change control, budgetary performance, etc., are other channels of industry where office automation may be instituted.

"More and more paper is being produced, and it is becoming increasingly difficult, at the decision-making level, to obtain quickly from this vast accumulation of information the data of greatest significance and meaning," he explained.

The function of the information systems being created by Ryan Transdata is to digest the raw data, sort out significant items and present these to the human observer in a meaningful form.

A simple application of Transdata unit would work something like this: An executive seeking certain information need only press coded keys on a box-like keyboard. Immediately, the documentary material, stored on microfilm or magnetic tape in a small compact area, perhaps the building basement, is automatically presented to a scanner for projection to a viewing screen on the executive's desk.

If a printed copy of the material is desired, another key would operate a machine for automatic copying from the screen.

"Automation of office functions not only would reduce the staggering volume of paper work, but would provide essential data much faster and sharply reduce the floor space required for filing and stenographic facilities," Alexander said.

"It is estimated that 25 percent of a business's floor space is devoted to such services, representing a sizeable expense. Existing techniques in office automation are too costly and cumber-

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WILLIAM G. ALEXANDER
President
Ryan Transdata, Inc.

FRED P. CIAMBRONE
Vice President
Ryan Transdata, Inc.

NEW SUBSIDIARIES

New Firm Located At Canoga Park, California, Will Specialize In Communication Problems

A new Ryan subsidiary — Ryan Communications, Inc.—has been created to tackle the increasingly urgent problems in the widely varied fields of high-frequency and microwave, wire, and space-aided communications.

T. Claude Ryan, President of Ryan Aeronautical Company, said the corporation is located in Canoga Park, Calif. Only recently, the formation of Ryan Transdata, Inc., a company entering the data handling field, was announced. Since the two subsidiaries are operating in fields that are related, their activities are expected to be mutually advantageous, Mr. Ryan said.

Ryan Communications, Inc., will develop solutions of specialized communications problems for military, governmental and private industrial customers.

"As military weapons, government activities and private industry operations become more complex, the requirements for transmission of the increasing volume of data present greater challenges," explained Dr. Frederick E. Bond, president of Ryan Communications.

RYAN
COMMUNICATIONS

"Communicators are now looking not only into space to provide additional traffic capacity but are working closely with scientists in varied fields—such as physicists, chemists and aerodynamicists—to help solve these problems," Bond said.

Ryan's new subsidiary will perform systems analysis and planning studies, applied research and advanced development, pilot production, installation and field engineering of communications systems. Development studies will ultimately lead to creation of communications hardware by the new firm.

Harold F. Meyer, Executive Vice President of Ryan Communications, has for the past three years been Co-Manager of the Communications Systems Department at Thompson-Ramo-Woolridge together with Dr. Bond. Their contributions in the study of satellites as communication relays in space to provide improved long-range propagation media has attracted international attention.

Dr. Bond is a veteran of 19 years in military communication, radar equipment research-development and system planning and analysis. A native of Philadelphia, Pa., he received his Bachelor of Science degree in Electrical Engineering at the Drexel Institute of Technology, his M.A. in Electrical Engineering at Rutgers University, and his doctorate in Electrical Engineering at Polytechnic Institute in Brooklyn. Dr. Bond has been active in

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DR. FREDERICK E. BOND
President
Ryan Communications, Inc.

HAROLD F. MEYER
Executive Vice President
Ryan Communications, Inc.

4
NAVY
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(OFFICIAL U.S. NAVY PHOTOGRAPH)

SEEK OUT, KILL!

'COPTER-DOPPLER COMBO SPELLS DEATH FOR SUBS

By T. A. CORONEL
Electronics Research Engineer
Ryan Electronics, Division of Ryan Aeronautical Company

The past decade has seen the helicopter grow into a sophisticated primary weapon, transport and all-round utility vehicle. During the same period Doppler radar has advanced to its present status of an accurate, lightweight, self-contained navigation equipment.

Ryan continuous-wave Doppler radar, as a basic velocity sensor, provides information that is ideally suited for use in the automatic control of a helicopter, both in hovering and directional flight. This capability was recognized in the early stages of Doppler radar development, by Ryan Electronics. As a result, Ryan C-W Doppler radar is teamed with the helicopter to provide one of the most versatile anti-submarine warfare weapons in the U.S. Navy's arsenal. A weapon capable of day-and-night and all-weather operations. The capabilities of this remarkable team, however, were only partially realized until the advent of automatic stabilization equipment (ASE) for the helicopter. Now, this combination relieves the pilot from burdensome flight details. He no longer needs to estimate wind force and direction or make manual corrections to the controls to compensate for these factors, but can concentrate on keeping station, avoiding other ships and aircraft, and executing the search and attack phases of his mission.

THE HELICOPTER teamed with Doppler radar is a weapon capable of all weather conditions as depicted (opposite page) by Ryan Artist Carl Bair.

The rapid development of the helicopter is largely a result of the military need for capabilities that only this equipment currently possesses. Consider the prime U.S. Navy application of the helicopter in anti-submarine warfare. It provides a means to detect, track, and kill enemy submarines. It speeds, with the aid of precise navigation, to the contact area, comes to a hover, and dips its sonar. If contact is obtained, it may move to a new sonar dip area to obtain an accurate fix on the submarine. It can outmaneuver the submarine, and yet it has the capability for dipping sonar at zero speed.

In 1954 the U.S. Navy and Ryan Electronics began tests using Doppler radar to sense a zero heading, drift, and vertical velocity condition to assist the pilot in conducting the relatively difficult hovering maneuver. These tests led to the development of the Ryan AN/APN-97A Ground Velocity Indicator, and later to the production of the advanced, high performance Ryan AN/APN-130 Navigation System for helicopters, airships, and other VTOL applications.

The AN/APN-97A Ground Velocity Indicator serves as a small, compact hovering and navigation device which weighs only 35 pounds. The AN/APN-130 system, with a weight of 71 pounds, can operate at higher altitudes than the AN/APN-97A, and it provides increased accuracy in velocity measurement and an increased vertical speed range. Both systems have the particular ability to operate with automatic stabilization equipment used in helicopters and other VTOL vehicles.

There are many interesting military and civilian uses for the helicopter, but the anti-submarine warfare (ASW) application is of prime importance. It must have an all weather, day-and-night capability, since enemy submarines are not limited by these factors. This requirement has led to the development of a flight control system capable of fully automatic operation. The automatic features can be considered in two areas—automatic stabilization and automatic navigation, in both of which Doppler plays an important role as a basic sensor.

Important phases of a typical ASW maneuver involving the use of helicopters in an ASW screen are station keeping, search, and attack. Let us assume that a group of ASW helicopters and their parent carrier have taken off under low visibility conditions, and

(Continued on Next Page)

the pilots are preparing to depart for their screen stations. We also assume that the helicopters have automatic Doppler navigation and ASE installed. While still in hovering flight each pilot establishes a programmed rate of turn to the desired direction of turn; he then commands cruise altitude and heading speed, and adjusts drift speed to maintain the desired ground track. The helicopter flies automatically to the screen station, while the pilot monitors his progress on an automatic plotting board. Upon arrival at his station, the pilot commands zero speed and desired hovering altitude. With no further manual aid, each helicopter comes to a solid hover.

While on station, the helicopters conduct a series of sonar dips, between dips advancing along a given base course with the screened unit. The range capability of the sonar determines the distance between hovers; and the speed of advance of the screened unit and sea conditions determine the time of such hover. When contact is made, the finder holds contact, and the killer helicopters, armed with homing weapons, are guided to the attack position.

Automatic transition to hover and automatic hovering flight, using inputs from a Doppler velocity sensor, are now routine maneuvers. Automatic directional flight with Doppler sensor inputs, has also been conducted successfully, and it is expected that this maneuver will soon be routine in high performance, multi-engine helicopters.

The automatic stabilization equipment is an electro-mechanical system which can, with the proper inputs, fly the helicopter automatically. The system stabilizes the attitude, altitude, and power of the helicopter by applying differential electrical signals to servo motors.

The Doppler sensor supplies the pilot with references to the earth's surface during normal level flight. In the automatic hover mode, the ASE supplies the necessary corrective signals to the helicopter controls to maintain the zero velocity condition.

Automatic stabilization and flight

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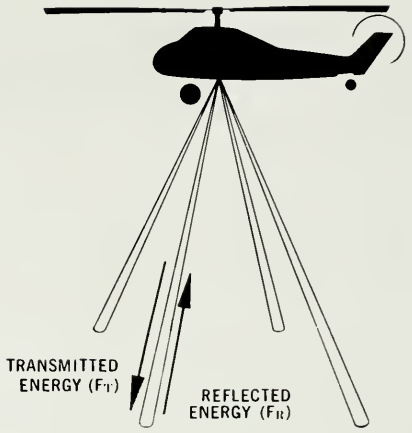

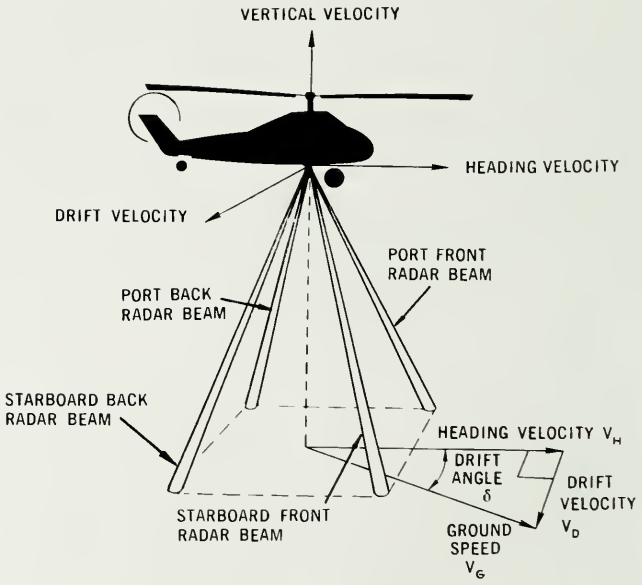

RYAN C-W RADAR Doppler four-beam navigation set as shown in above sketches is designed to detect fore and aft motion (heading speed), left and right motion (drift speed), and up-down motion (vertical speed) enobling helicopters to maintain sustained precision hovering even under the most adverse weather conditions.

French Business Plane Demonstrated

The French concept of a business executive plane is strictly in the luxury class.

This was demonstrated recently on arrival at the Ryan plant of the twin-jet, four-passenger Morane-Saulnier M.S. 760, which is touring the United States in an effort to arouse interest in such an aircraft.

The interest would have to be matched by considerable cash, about $400,000, based on estimated cost of producing such a plane in this country. Among the few elite owners of M. S. 760's are Middle East royalty and extremely wealthy private citizens in various parts of the world.

Ryan engineers and top company officials inspected the jet, which has a rated speed of about 400 miles per hour. Arrangements for the visit were made through L. E. Gehres, Ryan Security and Civic Affairs Manager, who was contacted by one of the group touring in the M.S. 760.

HONORED BY Boeing officials on his 10th Anniversary is J. B. Stalnaker, right, who is being honored by C. E. Blomquist, Boeing Material Group Supervisor for Major Assemblies, and D. M. Christie, center, Material Buyer Supervisor on the Ryan account.

Ryan Aide Wins Plaudits From Boeing

BOEING'S MATERIEL MANAGER R. W. Tilson, right, adds his words of congratulations as Jimmy Stalnaker rounds out ten years of service as Ryan's representative to Boeing. During his tour of duty at Seattle, Stalnaker has seen nearly $120 million dollars worth of Ryan assemblies flow into the Boeing plant.

Stalnaker Ends 10th Year At Boeing

A full decade as Ryan's resident representative at the Boeing Airplane Company in Seattle, Wash. has just been observed by J. B. "Jimmy" Stalnaker, Jr., who holds the record for length of service of any vendor representative at the big Pacific Northwest plant.

Boeing officials took cognizance of Stalnaker's 10th anniversary by honoring him at a luncheon and publishing an account of his service in the plant newspaper.

His employment at Ryan dates back nearly 19 years—to January, 1942—and his decade at Boeing spans two of the largest subcontracting projects ever performed by Ryan, the fuselage sections for the KC-97 and KC-135 tanker-transports.

During the 10 years he has been stationed in Seattle, Ryan has delivered to Boeing approximately $120 million worth of parts, sections and tooling for these and other planes, including the 707 commercial transport, the C-97 cargo plane, and the B-50 and B-52 bombers. This would average about $1 million a month in business.

Solar Engine Possibilities Tremendous

Sundstrand's 15-kw Solar Power System Expected To Run Full Year

BY CHARLES D. LA FOND
Washington Correspondent
Missiles and Rockets Magazine

Editor's note: Permission to reprint in the Ryan Reporter was granted by the publisher of MISSILES and ROCKETS.

BACK SIDE OF SOLAR RAY REFLECTOR being built by Ryan will have this appearance. W. M. "Mac" Cattrell, administrative director of project, displays sample of lightweight aluminum mirror to which has been welded aluminum foil lattice structure designed to reinforce and maintain close contour of the mirror surface. This experimental part was made to prove feasibility of this type of structure for space use.

Sundstrand Corporation is currently developing the biggest solar mechanical engine for the U.S. military which is expected to fill a serious gap in the space-hardware time table. The Ryan Aeronautical Company is participating in the project, having been assigned the task of building a solar ray reflector model for the vehicle.

Announced in June, a $1-million contract from the Air Force ARDC's Wright Air Development Division, makes Sundstrand's Denver Division responsible for research, design, and development of a breadboard 15-kw power system for space-vehicle applications. The potential of such a system could be tremendous in later production phases because of the diverse applications possible.

SIMILAR—18th Century print shown on opposite page bears a striking resemblance in shape and size to a solar ray reflector model being designed by Ryan. Engraving from "The Fisher Collection of Alchemical and Historical Pictures."

The contract was awarded to a team, of which Sundstrand is prime. Other companies participating in the 15-month program besides Ryan are the Goodyear Aircraft Corp., and Jack & Heintz. Ryan and Goodyear are principals in a 6-month development competition for the solar collector concentrators (mirrors). Ryan is developing rigid metallic dishes; Goodyear will design plastic inflated concentrators. Jack & Heintz will provide brushless alternators.

Expected to weigh 819 lbs., the solar mechanical engine will be designed to operate continuously and unattended for approximately one year, according to WADD.

Essentially, this will be a closed Rankine-cycle power conversion system, using rubidium as the working fluid. Rubidium was selected to achieve from 500-800°F increase in operating temperature over mercury, which is used in more conventional systems.

The power system when deployed will use a 40 ft. solar radiation concentrator. The big paraboloid, located between the satellite payload and the power unit, will be folded during transit and must be opened and oriented as soon as the orbit is established.

During deployment, the concentrator will be unfolded and the engine extended to a precise position for maximum operating efficiency.

Orientation of the concentrator and power package will be accomplished by a sun seeker, accurate to within 0.1 degree. Solar energy can then be directed by the concentrator to the power package for engine operation. A thermal storage unit in the power package will absorb sufficient solar energy to continue engine operation as the satellite passes through the shadow phase of its orbit.

A major unit in the system, the concentrator also is a major headache. Two mirrors are now being considered for use with Sundstrand's engine.

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D-8 Up 1,200 Miles!

Aerolab Nuclear Space Probe Scores 'Firsts'

READY TO GO is Argo D-8 rocket, developed and built by Ryan Aerolab for first West Coast launching of a space vehicle by the National Aeronautics and Space Administration recently at Naval Missile Facility, Pt. Arguello, Calif.

Missile Lands Right on Target Area

Information on radiation activity in the area in which man will someday guide his spacecraft is due shortly from the Goddard Space Flight Center, Washington, D.C., as a result of a completely successful firing of an Argo D-8 (NERV) rocket from Pt. Arguello, Calif., on September 19.

The launching and recovery of the National Aeronautics and Space Administration NERV (Nuclear Emulsion Recovery Vehicle) will make it possible for NASA to use three Argo D-8 backup missiles for other experiments.

So successful was the firing, that no less than four 'firsts' were recorded during the 37-minute flight. These included: Highest altitude achieved by any space vehicle recovered to date; First flight test of the four-stage solid propellant Argo D-8 designed and built for NASA by the Aerolab Development Company, Ryan Aeronautical Company's Pasadena subsidiary; First NASA launch from the Pacific Coast; and the capsule contained the first living organisms ever sent so far into space by this country (previous record was approximately 360 miles).

Another experiment, removed from the vehicle at the last moment to avoid possible complications, would have measured micrometeorite density. It consisted of a finely polished lucite shield, on which craters would be examined to determine the velocity and mass of micrometerorites encountered.

The capsule traveled a distance of 1,200 miles southwest from its pad at the Pacific Missile Range, landing within the predicted dispersion area and approximately 130 miles from the nominal impack point, designated as 'Zulu' point. Success of the NERV shot depended completely on recovery of the capsule as data could not be telemetered from the payload. The D-8 reached an altitude of 1,200 miles during its historic trek.

A Lockheed WV-2 search plane from the Pacific Missile Range sighted the green dye marker and the 83-pound recovery capsule bobbing in the water at 10:17 a.m. Plane crewmen guided the Navy destroyer USS Rowan to the impact point where the undamaged payload was recovered in less than three hours following the firing.

The Rowan later transferred the capsule to the attack transport Paul Revere—which returned the nose cone portion containing the payload materials, to San Diego. The payload was then forwarded to the Goddard Space Flight Center, Washington, D.C., for study and analysis.

Officials praised units of the Navy's First Fleet and Pacific Missile Range aircraft participating in recovery operations, and also pointed out that the NERV program exemplified cooperation between industry and government teams working in the national space program.

The rapid location and recovery of the capsule, vital to the success of the experiment, were made possible largely by the accuracy with which the impact point had been predicted. Aerolab, in cooperation with NASA Langley Research Center, was responsible for vehicle performance, trajectory, dispersion, and wind-effect studies. Trajec-

NERV CAPSULE is retrieved from Pacific by sailors of destroyer Rawan less than three hours after Ryan Aerolab Argo D-8 rocket boosted the instrumentation pack.

SPACE CAPSULE studied after recovery by (l to r) Sam Urcis, Ryan Aerolab Project Manager for NERV; VAdm. C. L. Melson, First Fleet Commander; Dr. John Naugle, program manager for NERV; and Capt. A. R. Olsen, skipper of the transport Paul Revere, which returned the nose cone to San Diego. Missile was airborne 37 minutes.

tories and dispersion were calculated using the IBM 704 and the Pacific Missile Range IBM 709.

Although machine programs aid accuracy considerably, trajectory and dispersion are heavily dependent on drag and other factors which cannot be determined until the vehicle has been flown at least once. Therefore, Aerolab's vehicle and propulsion analyses proved quite important.

Last minute trajectory computations were as follows:

1. Launch angle corrections were determined as wind data were received. Flight time was set for the time when the lowest winds were expected. Planned nominal launch angles were 83° quadrant elevation and 193° azimuth, while the vehicle was actually fired at 82.0° QE and 194.2° azimuth.

2. Another crew was assigned to Pt. Mugu, PMR, with the IBM 709 to determine the vehicle trajectory if radar tracking was lost before fourth-stage burnout. Actually, the vehicle was tracked past the fourth-stage burnout and the impact area was routinely processed by PMR personnel.

Accuracy of the impact predictions may be gauged by the fact that the fourth-stage burnout velocity shown by radar records was only two percent off the predicted value. This is the point where all guesswork involved in prediction accumulated; therefore, two percent was considered extremely favorable. Actual impact point was at a range only 18 miles greater than the predicted range.

Basic objectives of the NERV probe were to expose nuclear emulsion to radiation at altitudes of from 300 to 1,500 miles to (1) measure the flux, composition, and energy spectrum of the particles of tbe lower Van Allen Radiation Belt and their angular distribution relative to the geomagnetic field; (2) measure the variation of these parameters with altitude, geographic position, geomagnetic latitude, and the intensity of the earth's field; (3) attempt to determine the source, history, and path of the particles and compare the experimental results with those predicted by various theories to see which agree; and (4) to determine radiation dosage as a function of position.

In addition to the nuclear emulsion package, the nose cone contained three packages of neurospora crassa (mold spores) to determine whether exposure to radiation in space causes mutations in subsequent generations. The recovered spore packages will be studied by scientists at Florida State University. A third experiment, designed to measure effects of micrometeorites, was abandoned at the last minute to avoid possible complications.

Analysis by Goddard Space Flight Center of the types and quantities of radiation recorded in the nuclear emulsion, and of the effects of radiation on the neurospora, will add to current knowledge of the radioactive hazards to manned space travel. This information will also contribute to the design of shieldings required in space-

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ANISTROPIC SATELLITES

(Continued from Page 5)

tropic metalized sphere. Sample descriptions will explain why.

In the checkerboard technique, the surface of the sphere is divided into a large number of equal areas alternately metalized and nonmetalized. For each nonmetalized area on one face of the sphere there is a corresponding metalized area on the opposite face. As a radio signal hits the sphere, part of the energy is reflected by the convex metalized area and part of the energy penetrates the nonmetalized areas to be reflected by the concave metalized areas on the opposite side of the sphere. The total energy of the signal that strikes the sphere is reflected, either backscattered by the outer convex surface or concentrated by the inner concave surface — with only half the weight of the metal used in Echo I. An important portion of the energy is thus reflected toward the earth.

In the dual polarization technique, the surface of the sphere also is divided into a large number of equal areas alternately covered with horizontal and vertical metallic stripes. For every horizontally striped area on one side of the sphere, there is a corresponding vertically striped area on the opposite side. With horizontally polarized radiation, for example, half of the incident energy is reflected by horizontal stripes on the front surfaces of the sphere, while the other half penetrates the sphere through the vertical stripes and is reflected by the horizontal stripes on the opposite side.

In the corner reflector technique, the sphere is divided into two hemispheres, one rotated 45 degrees with respect to the other, each hemisphere being made of four orthogonal corner reflectors. The incident energy is reflected in three different ways with one, two, or three successive reflections, depending upon the relative attitude of the satellite and direction of the incident beam.

In the multicone technique, the volume of the sphere is divided into a large number of concave conical reflectors whose apex angle determines the angle between incident and reflected beams. The same technique also can be used with concave pyramids instead of cones.

In the multilens technique, the volume of the sphere also is divided into a large number of conical volumes, the base of each cone being a dielectric lens of luneberg or conventional type. The incident beam is concentrated at the focus of the lens, reflected on a metallic surface, and retransmitted through the lens into a parallel beam either in the original direction or at a predetermined angle.

In the multistripe technique, the surface of the sphere is covered with oblique metallic stripes at 45 degrees of the sphere axis so that the stripes on one face of the sphere are orthogonal to the stripes on the opposite face. Since the satellite attitude is variable, the polarization of the transmitted beam is rotated until it is perpendicular to the metallic stripes on the front face. At that time, the beam penetrates the sphere, to be reflected by the opposite face acting as a concave spherical reflector.

In the multidipole technique, the sphere is covered with a large number of dipole arrays. In each array, the dipoles are alternately vertically and horizontally polarized, and so connected that the incident radiation can be retransmitted either in its original direction or at any predetermined angle. This technique is particularly interesting in the case of private point-to-point communications where the distance between the two ground stations and the satellite altitude are constant.

These are a few examples of spherical anisotropic satellites. However, nonspherical configurations appear to offer certain advantages and should be considered, too. A polyhedron, for instance, has a very high directivity in certain directions. As an example, each face of a 30-meter diameter dodecahedron has an effective area of 236 m^2, corresponding at 3 kmc to a directivity of 54 db—which is considerably more than that of Echo.

At least two techniques are available to improve a convex polyhedron so that most of the energy intercepted by its surface can be backscattered toward the earth. One technique consists of surrounding each face of the convex polyhedron with oblique walls. The other consists of replacing each face of the convex polyhedron with a concave pyramid.

Two regular polyhedra, the dodecahedron and the icosahedron, are par-

ABOUT THE AUTHOR

Maurice G. Chatelain is a native Parisian who has spent 30 years in research and development of radio, television, telemetry, antennas, space communications, and satellite systems. He was educated at the University of Paris and Ecole Superieure des Transmissions, and was graduated with a Master's Degree in electrical engineering. He has continued his graduate studies at the University of California Extension, San Diego, in electronics, physics, and space technology.

Chatelain was self-employed in Paris and Casablanca for 23 years and served two years in the French Air Force as chief of an early warning and communication network. At Ryan Electronics, he is a member of a team engaged in work on new concepts for space navigation and communications.

His numerous invention disclosures include the omnipolarization feed used for automatic tracking of the TIROS meteorological satellite and the spherical spiral antenna used for the TRANSIT navigation satellite.

Chatelain is a member of the Institute of Radio Engineers, the American Institute of Physics, and the American Rocket Society.

ANISTROPIC SATELLITES

(Continued from Page 22)

ticularly convenient for the application of these techniques. There also is an irregular polyhedron that probably is even better. This is the icosahexahedron, made of 18 square faces and eight triangular faces. Each face can be surrounded with 135-degree oblique walls in such a way that not only the front face but also the surrounding oblique walls will reflect the total incident energy back to its original direction. The front face represents the short range reflector used, for example, in FM and television broadcasting in mountainous regions. The eight adjacent faces and their oblique walls reflect the energy at angles varying from 45 to 135 degrees with the incident beam and constitute the wide angle or long distance reflector used for worldwide commercial and military communications.

An alternative technique consists of replacing each face of a convex polyhedron with a concave pyramid. For example, the 12 faces of a dodecahedron or the 20 faces of an icosahedron can be replaced with 60 triangular faces. This type of polyhedron seems easier to manufacture and easier to inflate in space, and still represents considerable improvement over the isotropic sphere.

These passive satellites have been primarily developed for global communication at microwave frequencies. However, it seems they also will be used at optical frequencies. The recent development of a light amplifier, where incoherent green light is amplified and transformed into a very narrow beam of coherent red light, will make it possible to use light waves for global and space communications. At that time, very directive reflectors will be required and anisotropic passive satellites, similar to those just described, probably will be utilized.

In the near future, active, stabilized communication satellites will be realized. More directivity will be obtained from new antennas under development. Again, the best directive antennas seem to be those that can be built on a sphere, folded during launching through the atmosphere, and inflated in space. Based on the helix or spiral, these antennas can receive a radio signal from one direction and retransmit it in any other direction by means of a switching device.

The multihelix antenna is a spherical array of conical helices and the metalized sphere constitutes the ground plane. These helices can be connected individually or by groups in order to obtain the required direction and beam width.

The multispiral antenna is a spherical array of spiral beam antennas, each of them made of a spiral director, spiral-driven element, and spiral reflector. Each spiral can be of the Archimedes or logarithmic type in order to obtain more directivity or more band width.

The spherical spiral antenna, developed in 1958 and now used for the Transit navigation satellite, also may be an excellent antenna for active communication satellites. It is composed essentially of a spiral conductor printed on the surface of a plastic sphere. The screw sense may be the same on both hemispheres, or it may be opposite in order to obtain a different polarization. It can be used as a dipole or as a slot antenna, and many different radiation patterns can be obtained by varying the screw sense of the spiral, the feed point phase, and the rotational position of one hemisphere with respect to the other.

Obviously, there are many anisotropic satellite configurations that should prove to be far more efficient than the isotropic design of Echo I. Echo's designers were resigned to the fact that its reflectivity would be low but anticipated that it also would be constant. Experience now shows that its reflectivity is highly variable, at microwave as well as at optical frequencies.

Studies completed at Ryan Electronics of anisotropic satellites indicate their reflectivity will still be variable, but tremendously higher than that of the Echo isotropic satellite.

A 200-foot communication satellite now is under development in the United States, and the scientific world will be waiting to see if this is merely a larger version of an experiment already tried—or if the opportunity will be used to test new and improved concepts.

Charnock Named Senior Pilot at Ryan Electronics

Ryan Electronics has named Irvin B. Charnock as senior pilot, reporting directly to J. R. Reichardt, chief of Administration at Kearny Mesa.

Charnock has joined Ryan Electronics after 15 years as an airline pilot and is flying the Division's DC-3, a demonstration and test bed aircraft for continuous-wave Doppler navigation equipment.

Most recently, Charnock was with Trans-International Airlines, flying both international and domestic routes as a captain on DC-6Bs. He also served as an FAA-designated check pilot.

On other airlines he has flown the DC-4, DC-3, Constellation and Boeing Stratocruiser, serving in various supervisory posts as well.

RYAN TRANSDATA

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some, and one of our jobs will be to develop unique, easy-to-operate, economical equipment," Alexander stated.

Transdata's new President estimated that the first Ryan units will be ready for the market within one year. A systems analysis staff, augmented by nationally known consultants, will analyze problems of individual companies. Specific equipments will be installed on a custom basis to fit the needs of the user.

Heading the new company is William G. Alexander, former General Manager of the Stromberg-Carlson Division of General Dynamics Corp., San Diego, whose diversified experience in the electronics field is widely known.

Alexander explained that in the first phase of the Ryan Transdata's operations, a group of highly specialized engineers and technicians at the San Diego plant have initiated design studies of equipment aimed at office automation—the swift transfer of data from a central storage area to the executive's desk. Equipments will include those needed to gather information to be inserted into standard computers, and those which will provide read-out of computer generated data.

Vice-President of Ryan's new subsidiary is Fred P. Ciambrone, who graduated cum laude from Clarkson College of Technology, Potsdam, N.Y. Ciambrone, who was also associated with Stromberg-Carlson for many years, held positions of assistant chief, production engineering; chief of methods improvements and processes; production and works manager, San Diego division; and systems manager of area communications, supervising development of the first field mobile communications system for the U. S. Army Signal Corps.

Both Alexander and Ciambrone are members of the San Diego Chapter, Western Electronic Manufacturers Association.

SPACE METAL SPOTWELDING

(Continued from Page 10)

interface resistance can be made nearly constant.

When the welding current is applied, the greatest heat build-up is at the interface of the metals, which is the area of greatest resistance. For this reason, the weld nugget forms equally at the contacting faces of the material.

Rapid quenching encountered in welding foil gages results in the requirement of accurate controlled follow up of the pressure system to prevent cracking and expulsion.

Because the total quantity of heat involved is small and concentrated, radiation and conduction losses are minor. The weld nugget solidifies almost immediately, yet not before the electrode pressure is removed or before satisfactory forging action is completed.

Also, with the extremely thin materials used, the size of each weld nugget is small, and the surface distortion of the metals due to follow-up pressure is negligible.

Using a wheel-type electrode advancing as much as 15 inches per minute, making 10 welds per inch, it has been found that the electrode pressure is maintained long enough to avoid cavitation. In the type of welding utilizing longer weld periods, excess heat is generated in the weld area. Thus the weld cools more slowly, making it impractical to maintain complete follow-up pressure with fast, repetitive welding such as the new method.

Under the company's Patent Plan, Fullerton, Leech and Heyser have joined with Ryan in applying for a patent on the welding innovation now being used successfully in Ryan production.

The system takes on an added importance in light of the increasing necessity for joining thin metals to thick in parts for space age rockets and missiles.

Ryan Communications

(Continued from Page 13)

numerous fields, including antenna and transmission line research, carrier telephone and telegraph transmission, combat vehicular and portable FM radio, digital data transmission, microwave relay and multiplex, fire control radar, high frequency transmitters and receivers, integration of anti-aircraft fire control systems, and tropo and ionospheric scatter systems.

Vice President Meyer has 28 years diversified experience in communications, including theoretical and experimental research, development, product design, program management, systems planning and analysis. He was born in New York City and attended Boston and Columbia Universities. Meyer is a member of the Institute of Radio Engineers.

Meyer has performed considerable research in the fields of anti-jamming techniques, communication theory, frequency control, high frequency antennas and transmission lines, ionospheric propagation, modulation and multiplexing, space communications systems, and transistorization. Meyer was instrumental in development of low frequency, high frequency and very high frequency radio receivers, and radio transmitters ranging from 50 to 500,000 watts.

During the time Dr. Bond and Meyer were co-managers of the Communications Systems Department, Space Technical Laboratories, they were responsible for systems analysis and applied research in space communications, digital data transmission, information processing, anti-jamming and secure transmission and detection, development of portable, airborne and ground communication and navigation systems employing advanced modulation techniques; and operation analysis in military communication requirements and applications.

KILLER 'COPTERS

(Continued from Page 16)

control along the direction of desired movement is readily accomplished by the ASE with the aid of inputs from the Doppler sensor.

A system which features automatic navigation as well as an automatic stabilization, in both hovering and directional flight, is particularly suited to the requirements of current helicopter ASW operations because relatively short distances are involved. Such a system would comprise the Ryan AN/APN-130 Navigation Set, a navigation computer group, an automatic plotting board, a true airspeed transmitter, a heading reference, and the automatic stabilization equipment. Because of its "local area" capability, the system would preclude the necessity of applying spherical earth corrections in the solutions to the navigational equations. It offers considerable flexibility in its concept, and can be readily adapted to the navigational requirements of long-range missions employing high-performance helicopters.

The automatic plotting board provides the primary navigational display in the system. Using a rectangular grid coordinate system, it would eliminate the need of a separate computer in this device. The Dead Reckoning Position Indicator (DRPI) may be used in helicopter ASW operations. As a local area display, it provides significant advantages in visual presentation, elimination of large wind errors and airspeed errors, and reduction of pilot work load in navigating. The DRPI shows present position and heading by means of an illuminated aircraft silhouette (bug) projected on to a translucent screen. A desired flight pattern or program drawn on a transparent overlay and placed on the face of the DRPI gives the pilot a graphic indication of his present position with respect to destination, base, and known obstacles in the area. This feature is of particular advantage in applications involving low level pattern flying.

Several available navigational computers can be used, in proper combination, to accomplish the functions of the navigation computer group, though some of the units would require modification to meet specific requirements of the over-all system. All of the computers considered employ a-c analog techniques which yield comparatively lightweight, compact units with high accuracy and a minimum of field adjustments.

T. A. CORONEL is an electronics research engineer in Ryan Electronics' Advanced Design section with responsibility for final preparation of technical proposals. His five years with the company include work on continuous-wave Doppler radar for target seekers and airborne navigation systems, and development work on radar, altimeters for lunar and planetary landing vehicles.

Coronel was graduated from the U.S. Naval Academy with a Bachelor of Science degree in naval engineering. His 12 years of active duty as an officer included six years in submarines, two years at the Naval Examining Center, and four years in surface ship communications, navigation, and electronics.

Thus far, computer operations involving true air speed, wind speed, and wind direction, have been avoided purposely to emphasize the independence of Doppler-equipped navigation systems with respect to these inputs. The provision of a fail-safe feature, however, demands the use of these inputs in the dead reckoning mode of operation.

The advent of high-speed, long-range atomic submarines has changed many of the tactical concepts of anti-submarine warfare. Helicopters also have been given increased performance capabilities with regard to range, speed, power and military load. Airships have long been used for extended ASW patrol missions. Hence the use of high-performance helicopters and other VTOL types of aircraft in long-range ASW search and attack missions is readily visualized.

Available Doppler radars, navigational computer displays, and helicopter automatic stabilization equipment provide the necessary features for around-the-clock, all weather operations. The necessary self-contained automatic features are also provided for both short-and-long range navigation.

Ryan Delivers First Q-2C To Navy

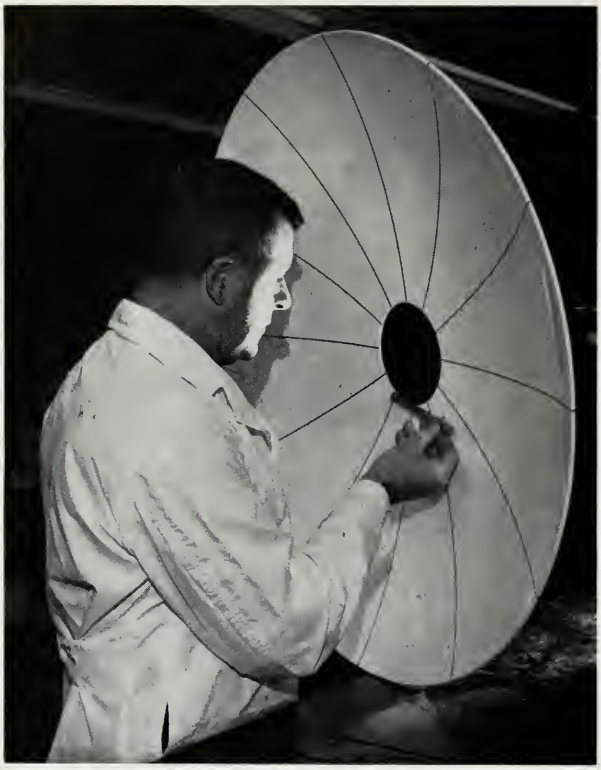
Delivery of the Ryan Q-2C Firebee jet target missile to the United States Navy was completed recently during ceremonies held at the Ryan San Diego plant. The target drones will be used in the Navy's operational training and evaluation program. Quantity output of the Q-2C for the U.S. Air Force has been underway at the Ryan plant since early this year.

Acquisition of the Q-2C gives the Navy a vehicle of high performance capabilities—a successor to the earlier Ryan KDA Firebee series, in current use with the Pacific and Atlantic Fleets. The new Q-2C jet targets, which may be ground- or air-launched, enable missiles to be evaluated through provisions for simulation of various types of aircraft.

Also, countermeasures equipment may be installed enabling complete evaluation of the Terrier, Tartar and Talos missiles.

A Support Guidance Committee, composed of nearly 30 Navy officers and headed by Lt. S. F. Hutchinson of the Navy Bureau of Weapons, Washington, D.C., met with Ryan representatives to discuss logistics support of the Q-2C program.

SOLAR ENERGY MIRROR MOCKUP



MOCKUP OF PARABOLIC MIRROR produced at Ryan in its advanced development work in solar energy and radar dish concentrators is examined by Al Coha, senior chemist, Test Operations. Different models will be built.

Solar Engine

(Continued from Page 19)

Ryan is developing a deployable rigid metal-leaf concentrator which uses lightweight aluminum construction. The second dish under consideration is a folded inflatable type, developed by Goodyear. At command, this package will be inflated in space and a paraboloidal portion rigidized by foaming. After rigidization, the unused portion of the balloon can be burned off.

Both types of concentrators show promise for this application. Each subcontract calls for delivery of 10-ft. models to the Air Force for exhaustive testing at the end of 6 months. The winner will continue development of the full-size dish.

Principal design problems to be faced in developing the big deployable mirrors are: 1) weight restrictions, 2) packaging, 3) deployment and space orientation, 4) maintaining accurate paraboloid after deployment, and 5) development of efficient reflective surface to withstand one year in space environment.

• *Solar flux trapped*—The power unit is a complex energy converter. Chief components of the engine are a cavity-type double boiler and flux trap, combined shaft unit and condenser-radiator. The flux trap and double boiler are both recent Sundstrand proprietary developments.

Serving as a kind of 1-way valve, the flux trap is the solar energy intake. The quantity of energy admitted into a specific size boiler opening can be increased by 20 to 25%, with a suitable flux trap. Size of the boiler opening is critical because of re-radiation losses. It's conceded that a larger opening would permit a greater amount of energy to enter the boiler; but it's noted that this would also allow an excessive amount of energy to escape. Thus, the more energy admitted through a minimum size boiler cavity opening, the greater the net gain.

Another advantage of the flux trap, Sundstrand believes, is realized in the geometric design tolerance of the concentrator. Fabrication cost of a concentrator increases rapidly with an increase in the required concentrator accuracy. The funnel effect of the trap diminishes this requirement.

In designing the double boiler, the primary aim is for high operating efficiency during collection of solar energy and optimum heat storage for use during the shadow phases of operation. Fabricated with an inner and outer cavity, the inner volume of the boiler is used for first-stage superheat and second- and third-stage reheat of the working fluid, rubidium. Sodium fluoride contained within the cavity provides for high-temperature heat storage.

The outer cavity, constructed around the inner cavity, is used as the initial boiler for the working fluid. Lithium hydride is contained within the outer cavity to provide for low-temperature heat storage. Through the proper arrangement and use of both inner and outer heat storage materials, a decided weight reduction of the system will be effected, company engineers say.

• *Superheated to 1750°*—Operation of the double boiler begins when solar energy, directed from the concentrator and flux trap, impinges against the walls of the inner and outer cavities. With the transfer of energy to the

working fluid, its temperature is raised first to approximately 1200°F in the outer cavity and then to 1750°F in the inner cavity.

• *Efficiency to be increased*—Alternator output at the nominal turbine speed of 24,000 rpm is 15.3 kw. This allows for 0.3 kw to be used for actuating flux-trap irises and control mechanisms in the power package. The alternator is a brushless, magnetic type unit with an all-metal rotor. Specifically designed by Jack & Heintz for high-temperature operation in a space environment, it employs ceramic insulation throughout.

In its earlier design state the solar engine efficiency was calculated to be approximately 21.7%. With recent state-of-the-art advancements such as the flux trap and double boiler, more efficient systems can be developed in the future, said Sundstrand.

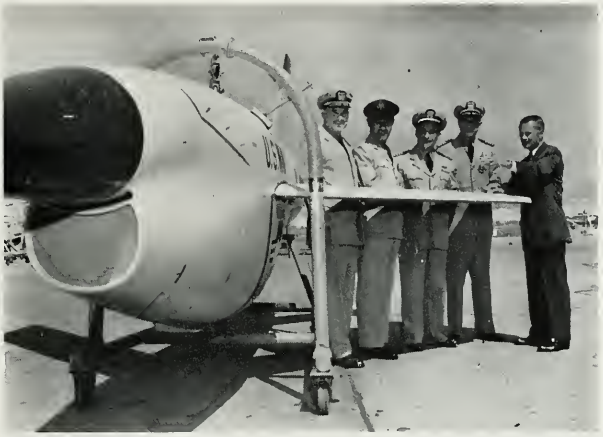
• *Problems*—There are many problems to be surmounted in developing any solar thermomechanical space power system of this type. Foremost among these are the unknown properties of rubidium and the design and materials for the solar concentrators.

Rubidium, one of a family of alkali metals, has extremely desirable characteristics as a working fluid. Theoretically, a rubidium system can be built with an operating temperature approaching 1800°F at reasonable pressures.

* * *

Specifications For Sundstrand Solar Mechanical System

Electrical output:	15 kw
Total system weight:	819 lbs.
Working fluid:	rubidium
Boiling temperature:	1200°F
Superheat temperature:	1750°F
Condenser temperature:	675°F
Cycle efficiency (turbine shaft):	0.260
Over-all electrical efficiency:	0.217
Solar concentrator parameters:	
Diameter:	40.5 ft.
Mirror/boiler efficiency:	0.74
Total weight:	315 lbs.
Turbine speed:	24,000 rpm



FIRST NAVY Q-2C Firebee jet target is delivered in ceremonies at Ryan San Diego plant, attended by high ranking Navy and Air Force officers. E. G. Uhl, Ryan Vice President-San Diego Division Manager, at right, points out interesting features of speedy missile to, left to right, Capt. R. L. Eldridge, Commander, Utility Wing Pacific, Brown Field; Lt. Col. C. R. Douglass, Chief, San Diego Air Procurement District; Capt. R. L. Savage, Bureau of Naval Weapons Representative, San Diego; and Capt. L. E. Harris, Assistant Chief of Staff for Training, Naval Air Pacific.

Ryan Personnel Begin Engineering Support Of Q-2C Program At Pt. Mugu

Ryan personnel have begun engineering support of the Navy's Q-2C Firebee evaluation program at Pt. Mugu, Cal., Naval Air Missile Test Center.

Edward D. Sly

Edward D. Sly, who will serve as flight test supervisor, has performed similar functions on Air Force and Navy Firebee programs in recent years at Holloman Air Force Base, N.M., and at Pt. Mugu. His most recent assignment was on the successful Q-2C flight test project for the Air Force at Holloman AFB.

Sly's employment at Ryan dates back more than 23 years—to April, 1937, when he joined the company as a final assembly mechanic.

In 1956, he set some sort of record for persistence in achieving a college degree. Eighteen years after first entering San Diego State College, Sly received his Bachelor of Science degree in engineering, with the second highest grade average in the entire class of 697 students. Because of his heavy work schedule, he was able to attend classes only part time.

But physical and chemical characteristics of the metal vapor are not fully known. For example, what will be its long-term effects on shaft bearings which depend on the fluid for lubrication? Also, what effect will it have on the alternator if leakage occurs?

Concentrator development offers more unknowns. Meteorite puncture effects probably can be made negligible. But sublimation in a space environment could be disastrous. Precise orientation must be maintained.

How will these units be tested? We can go only so far in the laboratory, even with the environmental test facilities available to the Air Force. The only true test will be with a fullsize satellite system in orbit for one year.

Sundstrand, Electro-Optical Systems, Ryan and many others feel the solar mechanical power system approach will bear early fruit.

First 'Astronautrix' Stars At Ryan Event

ON TOUR OF RYAN PLANT, Jerrie Cobb, America's first "astronautrix," examines jet engine of Q-2C Firebee target missile on assembly line. Her escorts are, left to right, Don Bennett, Corporate Communications; John van der Linde, Factory Manager; Art Billings, Jr., President, and Jim Pisciotta, Immediate Past President, Ryan Management Club.

Pony-tailed blonde Jerrie Cobb, America's first "astronautrix" who anticipates space flight with the matter-of-fact attitude of an inter-urban commuter, was the star performer at a fascinating "press conference" before 225 members of the Ryan Management Club Thursday night, Sept. 29, in the U. S. Grant Hotel Palm Room.

The 29-year-old sales promotion manager of Aero Design and Engineering Co., Bethany, Okla., producer of the twin-engine Aero Commander planes, calmly faced the quizzing of four members of the press and a medical expert in describing her hopes of becoming the first woman to be placed into orbit.

She already holds the distinction of being the first woman to pass the same severe physical and psychological tests given the seven male astronauts now training for Project Mercury.

Although the government has not yet officially entered sponsorship of plans to send a woman into space, preparations are under way for Miss Cobb to be joined by 12 other women in space flight training next year.

Some of the points brought out during the two-hour interrogation:

Women don't get bored as easily as men in situations of sustained monotony—hence have a psychological advantage in space flight over long periods of time.

Designers have not yet solved the problem of a space suit for women, taking into consideration different degrees of stress on different parts of the body.

Women are lighter than men, and need less oxygen, thus could be sent farther into space with the same amount of rocket thrust.

Women should go into space to gain knowledge about God's creation, and "help us with our life down here."

The panel of questioners consisted of Betty Peach, fashion editor, and Lew Scarr, reporter, San Diego Evening Tribune; Bryant Evans, science writer, San Diego Union; Dick Taylor, city editor, San Diego Independent; and Dr. Joseph Telford, past president, San Diego County Medical Society.

Charles E. "Bud" Porter, San Diego Chamber of Commerce Military Affairs Department Manager, was moderator, and Don Bennett, of Ryan Corporate Communications, was master of ceremonies.

Nuclear Probe

(Continued from Page 21)

craft. A spokesman for GSFC said that results of both experiments probably will be forthcoming. Results of the successful firing are also expected to increase the state-of-the-art in reentry and recovery of unguided space vehicles.

Commenting on the remarkable success of all aspects of the NERV experiment, T. Claude Ryan, President of the Ryan Aeronautical Company, sent congratulations to Aerolab Manager Lloyd Everingham and Forrest Warren, Chief Engineer, who were observers at Pt. Arguello. Arthur Schimmelman, Supervisor of Field Services; Samuel Urcis, Project Engineer; Stanley Charles and William Callaghan were responsible for Aerolab's contribution to technical performance of the Argo D-8.

Aerolab also was responsible for selection of a vehicle suitable for the demanding mission of payload recovery. Aerolab adopted the Argo D-8, originally designed by Aerolab for the Air Force, to the discrete requirements of the NERV experiment.

Eight Argo D-8 rockets have been built by Aerolab, four of which were earmarked for the NERV research program. Launch crews were prepared to assemble and fire a second NERV vehicle had recovery of the capsule failed.

Detailed performance engineering analysis was accomplished by Aerolab engineers in cooperation with the NASA Goddard Space Flight Center. In addition, Aerolab utilized analytical methods, techniques and engineering consultation made available by the Goddard Center and Langley Research Center's Space Task Group.

Aerolab engineers also contributed independent analysis and tests to determine vital aerodynamic characteristics of the slim, 62-foot Argo D-8 which weighs over 14,000 pounds. Fabrication, field assembly, pre-flight checkout and installation on the launcher of the D-8 was accomplished under technical direction of Aerolab by personnel of the Pacific Missile Range.

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The Argo D-8 vehicle is composed of four stages: First stage is a Thiokol Sergeant and delivers over 50,000 pounds thrust for approximately 25 seconds. It is assisted by two Thiokol Recruits, each of which develops 35,000 pounds thrust for about five seconds. Total weight of the first stage is about 9,000 pounds. Second and third stages are Grand Central Lances. Each weighs about 1,838 pounds with a thrust of 40,000 pounds for approximately five seconds. Fourth stage is an Allegheny Ballistics Laboratory X-248. It weighs about 550 pounds, and develops 3,040 pounds thrust for approximately 38 seconds. A burnout velocity in excess of 12,000 mph was attained after liftoff.

First three stages of the Argo D-8 are fin stabilized. The fins are canted, which causes the stages to spin, and also produces spin-stabilization of the finless stage with payload.

The payload section, designed and built by General Electric, has an overall length of slightly more than 42 inches and a base diameter of 19 inches. The re-entry cone is almost 17 inches long. In addition to the scientific experiments, programmer, and battery supply, the nose cone contains a parachute which is radar reflective and other location aids—a radio beacon, radar chaff, flashing light, and dye marker.

Incorporated in the recovery capsule were 25 emulsion disks consisting of silver bromide grains in a gelatin. The disks, with an average thickness of 600 microns, were contained in a tungsten cylinder which had a small port on the side. During the flight the cylinder was programmed to move forward, exposing the emulsion to radiation from an altitude of 300 miles, through an apogee of about 1,200 and down to 600 miles. At that altitude, the cylinder retracted and the nose cone sealed for re-entry. The emulsion disks were manufactured by Ilford, Ltd., of London, England, the only company in the Western world which makes this scientific material.

A 1 sq. cm. port in the shield admitted ionizing particles with energy levels over 5 MEV. The tungsten cylinder prevented particles of less than 150 MEV from entering the emulsion chamber except through the port. Because of the thickness, it requires almost two weeks to process nuclear emulsions.

For a stable re-entry and parachute deployment, the spin of the payload had to be reduced to below 40 rpm. A parachute assembly was attached to the back cover of the recovery vehicle. The cover had a bolt which fitted into a small mortar tube. As the capsule re-entered the atmosphere, gravity forces activated a pyrotechnic timer which, in turn, fired the mortar, ejecting the parachute along with 1.5 pounds of S-band chaff to aid radar acquisition. The chute was also radar-reflective with half of its 16 wedges having a silverized coating to aid detection.

The National Aeronautics and Space Administration was responsible for the overall project. Dr. John E. Naugle was Program Manager for NERV, while Charles E. Campbell of the NASA Goddard Space Flight Center was Project Engineer.

Moon Landing

(Continued from Page 11)

system problems as rendezvous terminal guidance, satellite vertical reference, gravitation control, and communication antennas.

The Aeronutronic subcontract calls for Hercules Powder Company to build flight configurations of a retrorocket motor.

Engineering, development, and production of the retrorocket will be carried out by Hercules at its Bacchus, Utah, facility.

Ryanite Appointed To National Post

Fred H. Wetmore, senior design weight engineer, has been appointed National Executive Secretary of the Society of Aeronautical Weight Engineers, Inc., a professional organization of 21 chapters with more than 1,000 members throughout the country.

F. H. Wetmore

Wetmore is past chairman and past treasurer of the San Diego chapter.

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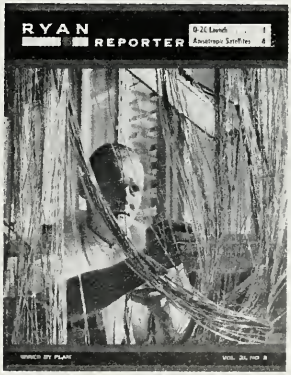
ON THE COVER

Spaghetti factory? Not quite. Photo reveals many of the hundreds of wires used in the electrical system of the ground support equipment of the Q-2C.



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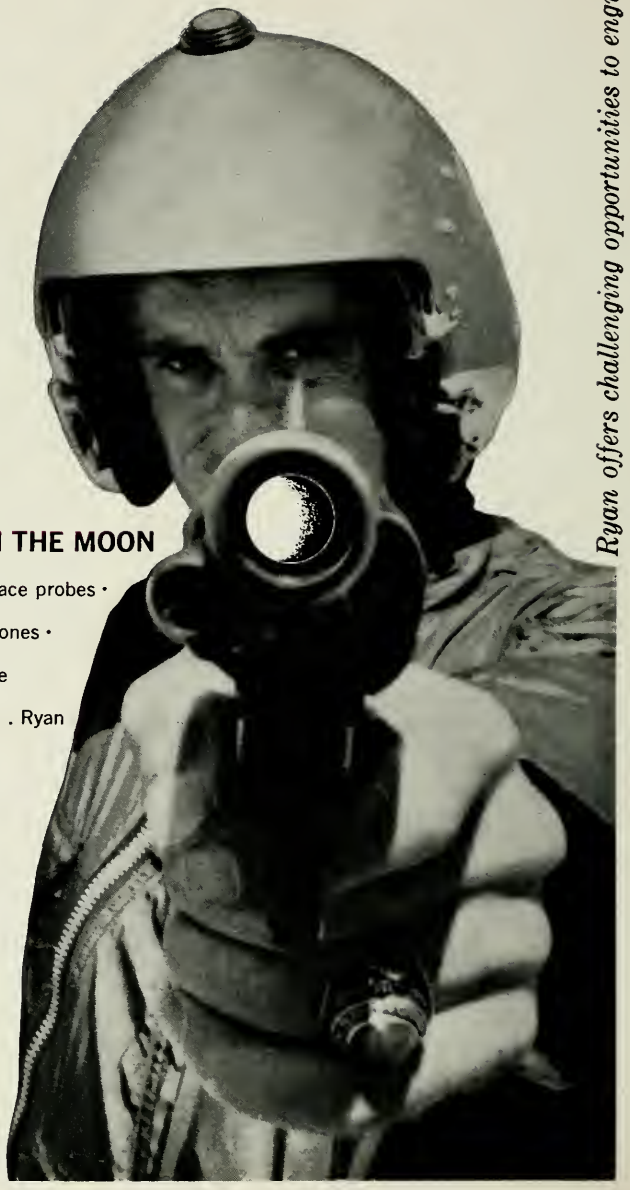

RYAN IS DRAWING A BEAD ON THE MOON

Through the design and development of space probes • Doppler radar sensors • recoverable nose cones • solar energy concentrators • ultra-thin space structures • multi-stage sounding rockets . . . Ryan is "shooting" for the moon . . . opening pathways to tomorrow's technology **TODAY!**

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RYAN REPORTER

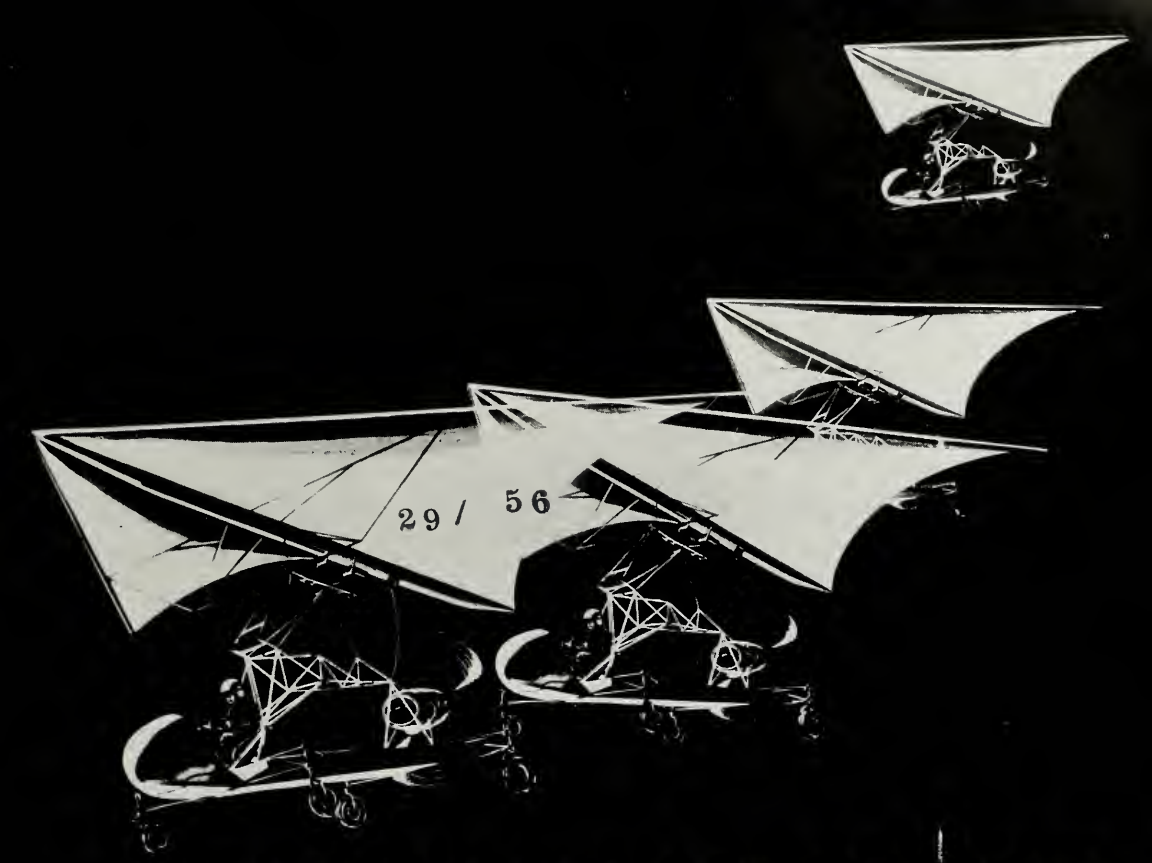
MOBILITY BREAKTHROUGH

VOL. 22, NO. 1

RYAN FLEX WING

"There shall be wings! If the accomplishments be not for me 'tis for some other."

LEONARDO DA VINCI—1505



. . . MOBILITY BREAKTHROUGH

Hailed as a new mobility concept, a flexible wing test vehicle has been built by Ryan Aeronautical Company to prove basic principles which can be applied to a wide variety of missions. After initial test by the company, additional flight research will be conducted under a contract from the Army Transportation Research Command.

The unique Ryan "Flex Wing," developed by the company's Aerospace Division in San Diego, California, employs a flexible wing. Such wings, in the Ryan test bed and in other configurations, can be packed into a very small space and quickly deployed to provide a large aerodynamic surface with high lift properties when used with rigid or inflatable leading edges.

"Applications of the flexible wing are limited only by the imagination of military planners," said Major General Richard D. Meyer, Principal Assistant for Aviation, Office of Army Chief of Transportation, in his announcement of the contract for flight testing and engineering application of the test vehicle.

"The Army has a great interest in this program, in which Ryan took the initiative to provide a test vehicle at its own expense.

"This is the world's first manned, powered version of the

basic flexible wing concept, and we will be able to obtain information, with a man in the vehicle, that we could get in no other way."

Consisting of a membrane of flexible material, in contrast to the rigid surface of conventional wings, the Flex Wing is based on an original concept by Francis M. Rogallo of the National Aeronautics and Space Administration.

"The beauty of this plane is in its lack of artificial stabilizers," H. C. Cotton, Manager, Advanced Systems, Ryan Aerospace Division, pointed out. "The wing is an extension of the principles first explored by Leonardo da Vinci and other pioneers of flight."

As a manned, powered vehicle, the Flex Wing can be adapted to combat utility vehicles to carry personnel, high priority cargo, litters and other equipment in combat zones—functions in which the Army Transportation Corps is vitally concerned.

Although the test vehicle will be propelled by a conventional reciprocating engine, the Flex Wing may also be powered by turbine or rocket engines to conform to specific missions.

And, as in the recently announced Saturn rocket booster recovery system, the Flex Wing can perform as a glider capable of carrying tremendous loads from outer space back to earth.

The Army-funded flight program will consist of ground tests, taxi and lift-off tests and performance, stability and control evaluation. Data obtained will be applicable to the design of similar vehicles intended for many other uses.

Impressed with the enormous potential of the Flex Wing for Army purposes, General Meyer declared:

"In addition to carrying personnel and high priority cargo, the Flex Wing can be employed for ambulance, survey, wire laying, liaison and other assignments.

"Helicopters, towing the Flex Wing as a glider, will be able to transport six times as much weight in troops, cargo or fuel as the helicopter alone can carry. In this respect the helicopter capability is greatly expanded, enabling it to transport large amounts of cargo between bases and from ship to shore.

"All these applications are possible because the Flex Wing is a remarkably stable, simplified, inexpensive concept which provides greater lift per unit of weight than conventional wings or parachutes.

"The Army is looking for vehicles that are different from the high-flying planes of the Air Force and the Navy. We want planes that can snuggle in the nap of the earth, that can fly quietly, and that can take off in a cow pasture and land in a barnyard."

Sailmakers joined aircraft engineers and metal fabricators in producing the first Flex Wing.

The flexible triangular-shaped wing consists of a special rip-stop nylon coated with Mylar plastic which eliminates porosity.

The Mylar plastic is similar to the material used for the Echo space balloon. It can withstand weight of 20,000 pounds a square inch before breaking.

The wings' flexible characteristics permit convenient folding and storage in a small package the length of the keel.

In the flexible wing principle, a simple center-of-gravity control system is utilized. The wing can be moved by means of controls, either manually or by radio command, that provide maneuvering characteristics similar to more conventional aircraft.

In addition, a means of moving the wing keel fore and aft with respect to the body provides a method of trimming the aircraft for steady state flight conditions.

Inflated Flex Wing can recover nose cones and missiles.

The aircraft's flight trajectory is controlled by shifting the center of gravity with respect to the center of pressure of the wing.

Wing models already have been tested successfully in free flight and wing tunnel from subsonic velocities to speeds of nearly Mach 5 by the National Aeronautics and Space Administration at Langley Field, Virginia.

"The wing is inherently stable, even while carrying heavy payloads at sharply inclined angles," General Meyer reported.

Extremely low storage volume and exceptional light weight are among the

(Continued on Page 21)

For NASA, Ryan will evaluate Flex Wing to recover the Saturn booster, shown at Marshall Space Flight Center. Booster is 82 ft. long and weighs more than 60 tons.

RYAN RECEIVES FLEX WING CONTRACTS

Contracts from the National Aeronautics and Space Administration (NASA) and the Army's Transportation Research Command have been awarded Ryan for Flex Wing applications and a contract with the Marine Corps is being negotiated.

For NASA, Ryan is evaluating the Flex Wing as a means for recovering the huge first stage booster of the Saturn research space vehicle. The recovery system will be designed around a flexible wing glider which would deploy at burnout and carry the rocket back to a pre-selected site on land through remote command guidance.

This technique would save the expensive, 122,000-pound booster, for repeated re-use, which would otherwise burn out and fall back into the sea. It is 21½ feet in diameter and 80 feet long. Under construction at Huntsville, Alabama, and destined to contain the most powerful booster in the free world—with a thrust of 1.5 million pounds or 32 million horsepower—the Saturn is due for its first flight some time this year.

Flex Wing weapons drone is checked by engineers Cecil Craigo and Carl Friend.

Ryan will provide complete engineering and cost data for NASA on the application of the Ryan Flex Wing to the Saturn booster recovery. Saturn is expected to be the major high thrust vehicle for U. S. space exploration for a number of years. It is the first large rocket developed specifically for scientific space programs, earlier space achievements having been accomplished mainly with basically military rocket weapons. As the world's largest known rocket, it will be capable of sending multi-ton payloads into earth orbits, to the moon and into deep space.

ARMY CONTRACT

The Army contract, from the Transportation Research Command, is designed principally to demonstrate the feasibility of the Flex Wing concept to meet the Army's requirements for support of front line tactical operations. Such a machine could be adapted to combat utility vehicles to carry personnel, high priority cargo, litters and other equipment and perform survey, wire-laying and liaison missions in combat zones.

The flexible wing concept is also ideally suited for a variety of drone applications, including target, decoy, meteorological data gathering, reconnaissance and wire laying.

One of the simplest applications of the unpowered Flex Wing concept is as a helicopter-towed glider, to carry large amounts of cargo. Ryan engineers point out that a flexible wing glider, weighing 6,000 pounds can provide a useful payload capacity of 18,000 pounds, and as much as 98,000 pounds with reduced speed of the helicopter. Translated into fuel, this capacity could greatly extend the range of the helicopter.

Another glider application is for air drops, with the wing to be dropped from the prime mover in a folded position, then automatically deployed in flight. Inflatable keel and leading edges are being considered for this application.

A controlled glide bomb could be created by replacing the logistics payload of the air drop glider with a warhead. Extension of the range of cargo delivery and bombardment rockets could be effected by use of a flexible wing attached to a rocket, with the wing deployed when the vehicle approaches its apogee, followed by radio-controlled terminal guidance.

For infiltration and rescue operations, a flexible wing permits silent glide-in penetration, while retaining the capability of powered escape from behind enemy lines.

MARINE CORPS

For the U.S. Marine Corps, Ryan will soon apply the flexible wing concept to the use of drones to provide close support for Marine Battalion Landing Teams. The Flex Wing drone is a simple, portable, reliable method for detecting enemy positions, survey-

(Continued on Page 24)

With Flex Wing, helicopter can tow six times the cargo or fuel it can carry.

DATA FOR DECISIONS

Your Problem May Already Be Solved — By Someone Else

By William G. Alexander
Ryan Transdata

In the U. S. alone, we pay 1 billion dollars a year for outright duplication of R&D effort in doing over again the things that have already been accomplished.

Up to 6 billion dollars a year of R&D effort is misdirected because of a lack of knowledge of previous work. In other words, doing things differently from the way in which they would have been done had the scientists and engineers been fully aware of prior work in this field.

If the scientist and engineer could start with a full knowledge of the current state-of-the-art, we would in effect add up to 7 billion dollars per year of vital research and development to the U. S. fund of knowledge, *without spending one extra cent.*

We hear many alarming stories about the need for increased emphasis on training scientists and engineers in the United States. I agree that this is a vital thing; however, we are in a critical phase in our technological war with the communist world and need to take action which will yield immediate results. Giving our hundreds of thousands of existing experienced engineers and scientists the benefits of immediate, easy access to the data generated by prior research would be equivalent to adding *50,000 experienced* man years of effort to our side of the technological race each year.

It is a fact that the cost of not knowing is higher than the cost of putting a system in that would let us know. Russia is not asleep in this area. They have a seven story information retrieval headquarters in Moscow with a highly organized world-wide network of inputs. Each major Russian embassy in all the large countries of the world has departments set aside specifically to gather, condense and forward information to this Moscow center. The center processes and makes immediately available to their research scientists abstracts on books, research papers, magazine articles, patent disclosures and even newspaper articles on impending research from all over the world.

Transdata, the information handling group of the Ryan organization, is organized to attack this problem. Our charter covers all of the procedures, personnel, supplies and hardware to collect raw data concerning physical phenomena, human actions and transactions, to transmit raw data to processing stations, to store data pending, during and after processing, to manipulate data in a manner designed to provide timely and meaningful information and instructions and to present information to those persons who require it for the effective discharge of their responsibilities, and to feed back instructions to generate human or machine actions.

We will design systems to automate the paper work function of business and government operations with a prime objective of eliminating paper wherever possible. Our work will be associated with image processing, as well as data processing.

Transdata has set a rapid growth pattern as one of its objectives. This will be achieved through a four element program. Basic products will be added by acquisition; joint ventures on a world wide basis will add new products; company programs will yield advanced products and contract sponsorship will be sought for complex systems. All of these efforts will be directed toward an increased capability in the information handling field.

Data is used primarily for the transmission of intelligence from one place or person to another. In the majority of situations, the data is used to aid in the process of decision making or as a record for storage and future reference. This process of making timely intelligent decisions has presented a challenge throughout history and the task is growing more difficult as our society and the data describing it become more complex.

The storage and retrieval of data is one of the major problem areas faced by anyone contemplating work in the information handling field. Classification and indexing is a very formidable problem and one which must be properly solved if we are to be able to go back into our files and retrieve the significant data we desire.

Anytime anyone suggests putting an information handling or paperwork automation system into a company or government office, he immediately hits the block of the guardians of the capital investment bankbook, because it does cost money to study the problems and to install the equipment and to conduct the trial run. All of these steps must precede the reaping of the benefits of the system.

After reviewing these roadblocks, many people ask why I am foolish enough to expect this business to grow. My answer is best summed up by a story in a recent issue of Coronet Magazine. A shoe manufacturer sent two salesmen to a primitive country. In a few weeks a telegram was received from the first salesman stating, "Returning home, impossible to sell shoes here as everyone goes barefoot." The next day, the second salesman wired, "Mailing order for 52 pairs of shoes. Possibilities unlimited. Everybody here is barefoot." I choose to adopt the attitude of the second salesman, because there are two sides of this coin.

The average business can realize satisfying financial results from the use of advanced information retrieval, data entry, and presentation techniques. There are 3 million firms in the United States. 2.94 million employ less than 100 people. These small firms often play an important role in the economy of their home community and this is certainly true in San Diego. Any community which can offer an environment which will make these small companies more competitive will find itself in a position to attract them. A well planned and properly supported information center is one ideal way to do this. Let me cite one specific example: The U. S. Government issues many reports, bulletins and statistics which when properly digested and related to a specific business constitute a powerful planning tool. The small business simply cannot afford to hire the staff to digest this data, nor can the management afford the time to do this. Therefore, the small business is denied the full benefits of this type of service. Most large companies do have a staff to handle this data and find it a very valuable tool in their operations.

A regional information center might use the reduction of this data and the consolidation of the data into a form most useful to the majority of the small businessmen in its area as a very useful and worthwhile task.

Transdata plans to devote much of its effort to bringing the advantages of information handling techniques to small businessmen with emphasis on adding advanced data presentation techniques such as all-electronic wall displays, anticipatory displays, which show present trends extrapolated into the future with proper weighting for boundary conditions, such as market trends, capacity, etc.; time compression displays which emphasize the dynamic parameters of a situation and other tools which will aid the executive in making competitive decisions. An example of the possible benefits to be derived from modern data handling techniques was recently brought out in a newspaper article. A chain grocery company of Los Angeles used a computer to analyze six months of operation which involved 3,600,000 cases of merchandise sold in a 48 week period. The answers pointed the way to an improved marketing and handling concept which moved their sales per store and net profit ratio from a marginal condition to the highest in the industry. This is one small example of how modern information handling techniques can definitely add to the capability of an organization, whether it be a commercial business, a government operation, or a research laboratory.

The equipment that we will build will be ideal as a tie-in point to the regional information center to take the large amount of data that is available, integrate it into the current operational data of the company and present it to the individual business man or engineer in a form that will be useful to him.

The data central of this typical information handling system will follow this pattern: external data is received through conventional methods in use today, plus new techniques of speedmail, a proposed new postal service which offers same day delivery of mail anywhere in the U. S. and industrial facsimile which is used to transmit written data, charts, photos, etc. Internal data is entered through typewritten copy, handwritten memo, dictation and digital data entry devices. These digital data entry devices are used to enter bookkeeping, timekeeping, inventory and similar data automatically in a digital language. The data flows through the classification station where it is properly indexed and coded for future operations. Internally generated data is given a first order classification by the originator. However, the majority of external data will be uncoded. The classification

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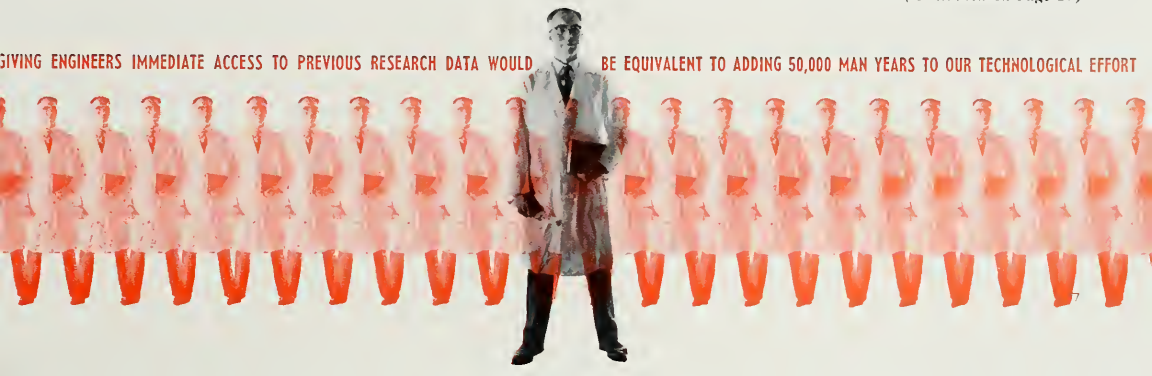
GIVING ENGINEERS IMMEDIATE ACCESS TO PREVIOUS RESEARCH DATA WOULD
BE EQUIVALENT TO ADDING 50,000 MAN YEARS TO OUR TECHNOLOGICAL EFFORT

THINK SESSION

RYAN SCIENTISTS AND ENGINEERS

Exotic terms unheard in the aircraft industry a few years ago dominated a recent "brainstorming" session of Ryan engineers and scientists engaged in the company's new aerospace projects.

Arranged by Edward Uhl, former Vice President and Manager of the San Diego Division, and William Wagner, Vice President, Corporate Communications, the meeting was held in a San Diego suburb. Creative approaches and revolutionary technological ideas were discussed in a round table symposium technique aimed at stimulating original concepts projected into long-range goals.

Bionics, time compression, data automation, energy conversion were some of the interesting areas examined and analyzed. William T. Immenschuh, Ryan Executive Engineer, stressed the great possibilities for research and application in bionics—the science of systems that are life-like in function—and the potential application of biology in engineering.

Dr. Karl Undesser, Head of the Ryan Astronics Department, lead discussions on improved radar and sonar applications of time compression devices and covered space surveillance and ground mapping by satellites.

William Alexander, President of Ryan Transdata, Inc., went into the need for improved automation of essential data flow and made a provocative attack on support documentation and data handling.

Floyd Cox, Manager of San Diego Manufacturing Pre-Planning, covered the complex manufacturing problems to be

"BRAINSTORM" BOLD NEW CONCEPTS FOR SPACE AGE

hurtled in this space age and forecast the new techniques used to fabricate huge space rockets.

The broad area of space communications was discussed with contributions by Dr. Frederick Bond, President, and William Fiden, Technical staff member, of Ryan Communications, Inc.

Carl Gottwald, Ryan Electronics Chief Engineer, provided original thoughts on electronics in educational programs and Robert Munk, San Diego Division Manager of Systems Integration, related military strategy and foreign policy to technological advances.

Armand Tanguay, Director of Advanced Programs at Ryan Aerolab, presented the subject of space probe systems and guidance and homing concepts. John Bowden, Chief of Advanced Design at Ryan Electronics, introduced altitude and velocity sensing problems with respect to deep space flight programs and discussed the possibilities of flights to Mars and Venus.

One of the principle subjects of the symposium session—bionics—was also the subject of a special meeting in Dayton, Ohio, recently under the sponsorship of Wright Air Development Division of the Air Force. At that meeting, Lt. General Bernard Schriever, ARDC Commander, stated that the Air Force hopes bionics will provide clues to improve weapons and the performance of the men who operate them.

"The use of living models as a key to the functioning of electronic and mechanical systems unlocks a new area of technology," he said.

It was pointed out that the Air Force is anxious to learn more about nature's ingenious techniques in creating microscopically small but extremely effective sensors. Among examples cited:

Rattlesnakes have a tiny infrared sensor between nostril and eye which is so sensitive it responds to a change in temperature of 0.001 Deg. Centigrade.

Some tropical fish can detect a change in the electric field of water as small as 0.003 microvolts per millimeter. Such fish can discriminate between two covered glass rods whose diameters differ by only two millimeters.

Moths upon which bats feed have a tiny hearing organ sensitive to the ultrasonic cries of the bat, enabling the moth to take evasive action. The best microphone for picking up bat cries can be made by attaching electrodes to the nerve leading from the moth's ear, one of the scientists pointed out.

Brig. Gen. Benjamin G. Holzman, Commander of the Air Force's Cambridge Research Laboratory, Mass., has pinpointed the ultimate goal of bionics:

"Missiles are all the rage, but the missile is a stupid beast. It only goes where you tell it to go. A manned bomber is infinitely more versatile than a missile. But a missile operated by a computer that works like a man's brain would indeed make the manned bomber obsolete. And this, among other things, is what we are searching for in our biology basic research."

Head man Art Akers checks "shoot" details.

By EDWARD L. HAYES
Supervisor, Photography

AKERS' DOZEN

...*The Men Behind America's No. 1 Jet Target*

"Umbilical" is plugged into Ryan Q-2C Firebee prior to launch from 60-ft. rails.

Reliability is composed of a number of things. Reliability is certainly an aspect of hardware and equipment but most of all, reliability is people.

Reliability comes in many sizes—from many sources.

When you buy a piece of merchandise of any dimension, you are in reality buying the trustworthiness of the firm which produced it, the men who build and operate it.

When you produce hardware in any degree of complexity, you are building integrity into solid form.

A complex and important member of the modern weapon team is the typical jet target. This target severely tests the defensive weapons of the United States.

The Ryan Firebee, a target known throughout the armed services for efficiency, economy and reliability is an example of trustworthiness in solid form.

Thirteen Ryan men, under the leadership of Art Akers, recently journeyed to White Sands Proving Ground with a contract to develop Ground Launch Systems and Techniques for the Firebee, furnishing a prime example of how reliability can be built by a baker's dozen of men.

It was believed that 33 complete XM-21 target missiles would be required during the run of the contract. Two flights per target missile before expenditure were estimated as probable, requiring 33 Firebees to conduct the contracted 66 flights. During this time Ryan engineers would have additional time to develop the Firebee ground rail and zero launch techniques to a point that would warrant use of *later* types of Firebees.

After only ten rail launch flights, it became apparent that the rail launch theory was no longer in the possibility stage, but was a reality, and the Army began scheduling the XM-21 target missiles as "Targets of Opportunity."

On the 30th of November, 1959, Akers' men launched the first XM-21 from the *zero-length* launcher. The target missile roared from the launcher,

climbed to 2,000 feet, and was recovered with no damage.

On December 7th, the same XM-21 target missile was again zero-launched, for another perfect mission. Since that time, this intrepid group has conducted a total of twelve zero-length launches, utilizing XM-21 and 61-E target missiles without a single mishap.

On October 20, 1960, Akers' men completed flight number 66, which had been previously estimated as the end of the ground launch development program on the XM-21's. Since that time they have supplied an additional 55 regular support missions utilizing the XM-21's, over and above the original total launches planned!

In the meanwhile, Akers' charges had accomplished a few firsts for the range: On November 10, 1959, they flew the first target missile ever to fly from one end of the White Sands Integrated Missile Range to the other and return.

This possibility for a target had been on paper for nearly eight years and had never before been accomplished.

Engineers launched the missile at "B" Station, eastward toward Fort Bliss, then turned it northward on range. At Holloman, technicians, shifted tracking radar and continued the missile to the extreme north end of the range, where a 180 degree turn returned the missile to the south end of the range for recovery.

On October 23, 1959, Akers' group conducted a low level flight, for 28,000 yards at an altitude of 750 feet above the terrain.

On September 16, 1960, target missile number 0006 (the first XM-21 to be zero-launched back in earlier days) was launched at "B" Station and flown uprange for a distance of 84,000 yards at an altitude of less than 700 feet off the deck. On the return trip downrange, target missile 0006 suffered a direct hit from a range missile system and proudly joined her ancestors during her sixth mission.

October 19, 1960, saw Akers' group launch and fly three target missiles in one working day.

On October 29th, target missile number 0032 successfully completed its sixth mission, thus becoming the

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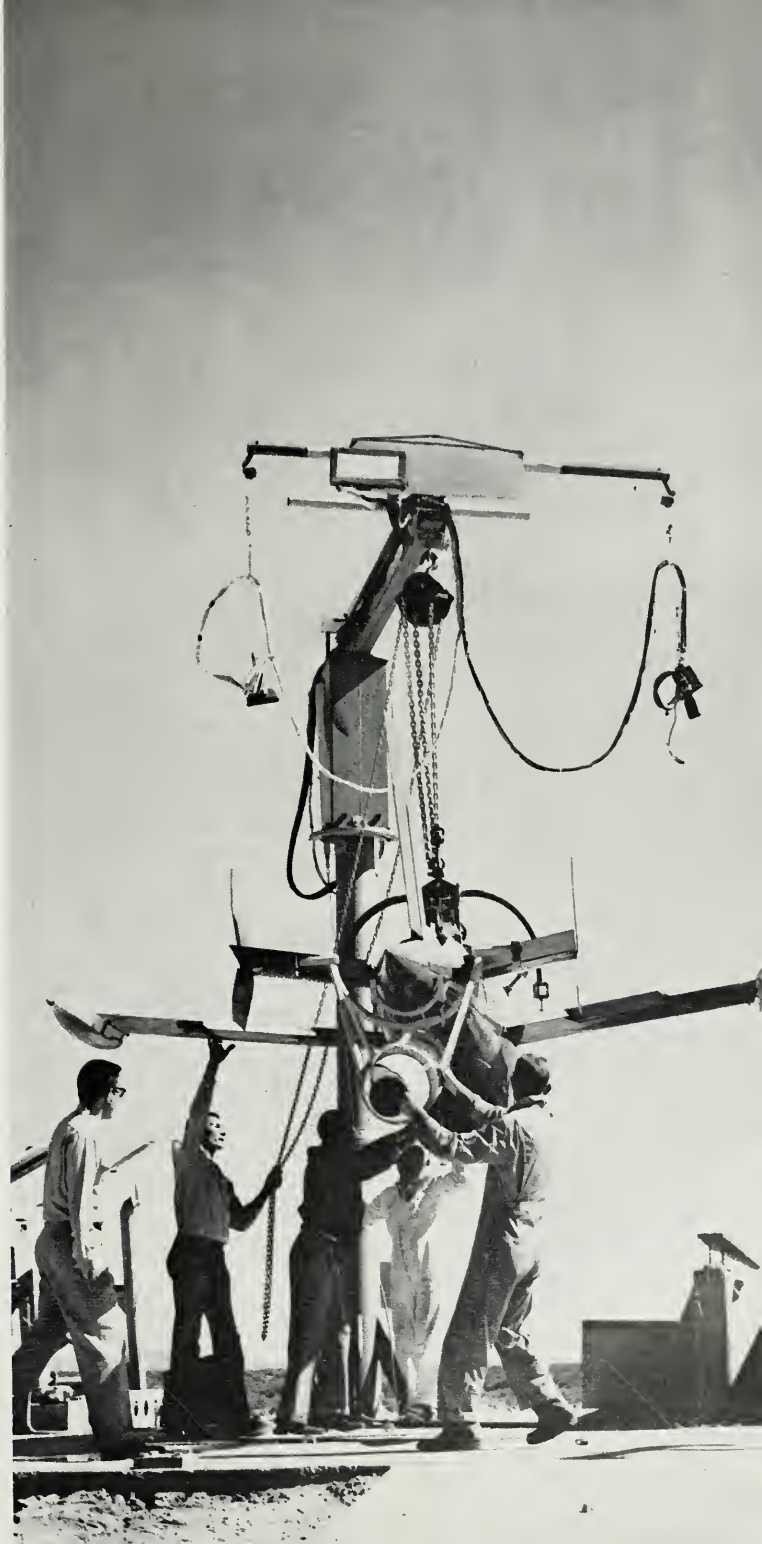

Ryan crew swings Firebee from cradle to launcher at White Sands Proving Ground.

The "bird" is prepared for final checkout by E. M. Baca (left) and Tom Caldwell.

current "champion" of the XM-21 series. That week also saw Ryan technicians launch and fly five target missiles, the record number for one week!

How did they do it?

By working the pre-dawn knife wind of the desert winter with tools so cold that they stuck to the bare skin.

By working from first light until long after dark.

By living, breathing, thinking jet targets twenty-four hours a day.

By teammate selection, not only for technical capability, but consideration of whether or not he would pull his weight—and more.

They had to be the kind of men who could take the unheard of and make it a fact, or throw away the rule book and improvise.

Art Akers tells a story of action, and quick reaction that can be part of a day's routine.

"A few weeks ago, we were preparing to launch a target missile and this particular bird had been so reliable that we didn't bother to have a standby for it. Count-down had gone to X-minus-4 seconds, at which time a series of events happened which we turned into a good thing. First, the target missile developed a short circuit and burned up the Generator-ON relay, and at the same time someone drove a large truck through the 2300-volt power lines which supplied power to the target missile launch station and missile system complexes. Instantly, communications were lost at "B" Station so we had no way of knowing what happened. After going back to "B" Station, I found out from Bud Miller what the story was. We were told it would be at least one-and-a-half hours before the missile people could get any power, and at least three hours before we could get our power restored. Bud Miller and I both knew that the "GEN ON" relay was shorted and would take three hours to replace. We hooked up the emergency systems, wheeled target missile number 0027 out of the ready hangar, gave it a quick weight and balance check, installed Jato and fired it under emergency conditions. The range never knew that had this fellow not driven his truck through the high voltage lines, we would have had to cancel the mission."

Setting up shop and working day in and out in the middle of a modern missile range is not a job for the faint-hearted. Without enough personnel to man every assignment, Akers' men worked out a system they called "cross training." Every man knew every other job as well as his own specialty. Every man cross-checked every step of the operation. His own and everyone else's.

Danger was routine. A prelaunch malfunction could instantly turn a launching pad into a seething, caustic inferno. After launch, any one of many natural or man-made interferences could zero-in tons of shattering death anywhere in the range area. There is no charmed circle of safety on a missile range. No day is a holiday from

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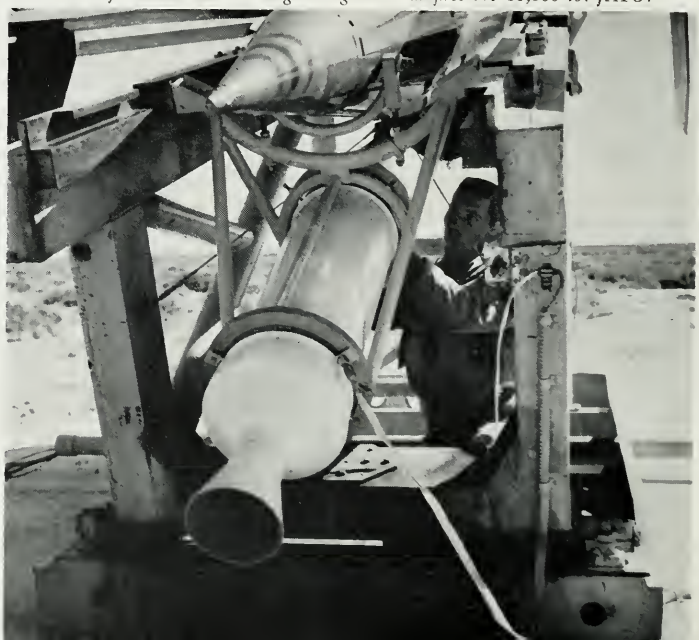
Last item before launch: attaching the igniter that fires the 11,000 lb. JATO.



RYAN RECEIVES NEW CONTRACTS...

IN ELECTRONICS

British Navy Wessex helicopters, shown in FLIGHT magazine photo, will be equipped with Ryan Electronics equipment.

Contracts totaling more than $1.5 million for AN/APN-97A Doppler navigation equipment and spares have been awarded Ryan Electronics, San Diego, by Sikorsky Aircraft Division of United Aircraft Corporation. Most of the equipment is destined for use in the U. S. Navy's HSS-1N anti-submarine warfare helicopters built by Sikorsky. Production on the two orders, which brings total Ryan business for the AN/APN-97 and AN/APN-97A to approximately $10.5 million, is already under way at the Ryan Electronics plant in Torrance, Calif.

Lockheed Aircraft Corporation has awarded Ryan Electronics an order exceeding $500,000 for AN/APN-122 (V) Doppler equipment for the Doppler-inertial system in the Navy's new Lockheed P3V-1 anti-submarine warfare aircraft. Ryan Electronics' AN APN-122 (V) has become standard equipment for a wide range of Navy aircraft including early warning aircraft, land-based patrol bombers, attack aircraft, anti-submarine seaplanes and carrier-based ASW aircraft.

Since the last issue of RYAN REPORTER, Ryan announced orders from the British Navy for special support equipment for the AN/APN-97A system, bringing the total business received on the British program to $2 million. Britain is installing the Ryan navigation sets in their Westland Wessex helicopters, in production for NATO service under licensing agreements with Sikorsky Aircraft.

Also announced since last issue was an $8 million contract from the U. S. Navy's Bureau of Weapons in connection with the Ryan AN/APN-130 Doppler navigation sets developed by Ryan Electronics. This contract addition brought the total business on this program to approximately $19 million and extended production on this equipment into June, 1962. These sets are being produced for installation in two of the Navy's most modern helicopters—the Sikorsky HSS-2 and Kaman HU2K-1.

IN SPACE TECHNOLOGY

Two sounding rocket projects within the National Sciences Program will be managed by Aerolab, it was announced recently in connection with new contracts from NASA to prepare at least six Argo D-4 and several Argo D-8 space vehicles to collect research data in space. The Argo D-4 and D-8 are four-stage research rockets developed by Aerolab. The D-4 can loft 120-pound payloads to 700 miles altitudes. The D-8 can boost 120 pounds to more than 1500 miles altitude at speeds exceeding 7,000 miles per hour. Aerolab will be responsible for payload engineering, launch preparation and data analysis in connection with the launchings from Wallops Island, Va.

Major new contracts for seven "Trailblazer 1" six-stage rocket vehicles to be used in the Department of Defense Advanced Research Projects Agency re-entry vehicle research have been awarded, recently, to Aerolab. These unique vehicles are to be used in a re-entry physics program for Lincoln Laboratory of Massachusetts Institute of Technology. The Aerolab Argo D-58 vehicle will fire the first three stages. In 300 seconds, the remaining stages will be 200 miles into space. Firing downward, these last stages will ram experimental payloads back through the earth's atmosphere at speeds up to 17,000 miles per hour.

Speeds up to 17,000 mph will be reached by these spherical rocket motors, built by Aerolab, for the Trailblazer I vehicles. Project will study atmosphere re-entry problems of space vehicles.

STATE OF THE ART - SOLID

Solid state frequency changers are in quantity production in the recently formed Avionics Department of Ryan's Aerospace Division and four other products have been launched, under the direction of John Short, Unit Chief.

The frequency changers were developed to meet the need for a more reliable unit, which does not employ moving parts, and assigned to the Aerospace Division under Ryan's policy of integrating capabilities.

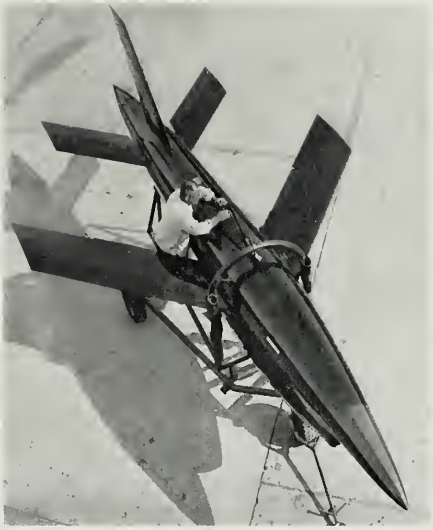
Bearing the "Minidine" trademark, the solid state devices are being delivered to Ampex Data Products Company of Redwood City, California, where they will power the FR-700 ground units of the new Ampex magnetic tape systems. Working with its airborne companion, the FR-700 can record two channels of wideband information over the frequency spectrum from 10 cps to 4 Mc. Amplitude response is flat to within 3 db over this range. The FR-700 also records two auxiliary information channels with a frequency response from 200 cps to 15 Kc.

A feature of the FR-700 is that its power supply requires no shock mounting or external cooling air. Two regulated DC supplies furnish plus and minus 24 volts and maintain output within 1 percent, with an input variation of plus or minus 6 percent over a temperature range of 25 to 85° C.

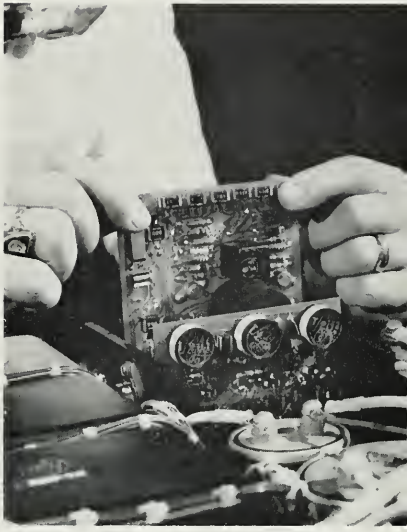
The newly-developed frequency changers provide a maximum of 800 volt-amperes of three-phase, 400-cycle power plus 10 amperes of 28 volt DC current, all from an input of 115 volts of 50 60 cycle line current. Ed. Dean, Manager of Avionic Sales, points out that the "Minidine" units are also adaptable to other applications in marine, automotive and aerospace fields.

Besides the frequency changers for the ground units of the Ampex system, Avionics also developed a 50-volt ampere inverter for the AR-300 airborne recorder. This unit weighs just over 4 pounds and converts 28-volt DC to a precise single-phase, 400 cps supply which drives a capstan motor.

For converting frequencies.



To give Firebee targets "enemy" bomber radar image.



To power Ampex magnetic tape recorders.

RYAN SWINGS INTO PRODUCTION ON SOLID STATE DEVICES

As a timer switch for a rocket in space.

Using solid state components, switching controls can be built without moving parts, thus eliminating the need for mechanical relays and providing greater reliability through invulnerability to shock and vibration. Recently, Ryan completed timer-intervalometers for use in the Argo D-5 sounding rockets.

Deliveries have also been started on traveling wave tube amplifiers for radar augmentation of the Ryan Q-2C Jet Firebee targets at the Naval Ordnance Test Station, China Lake, California.

Chaff dispensing timers are being provided for use on the Air Force Q-2C Firebees. These units provide a countermeasure capability to the target by setting the release of chaff in successive increments during flight.

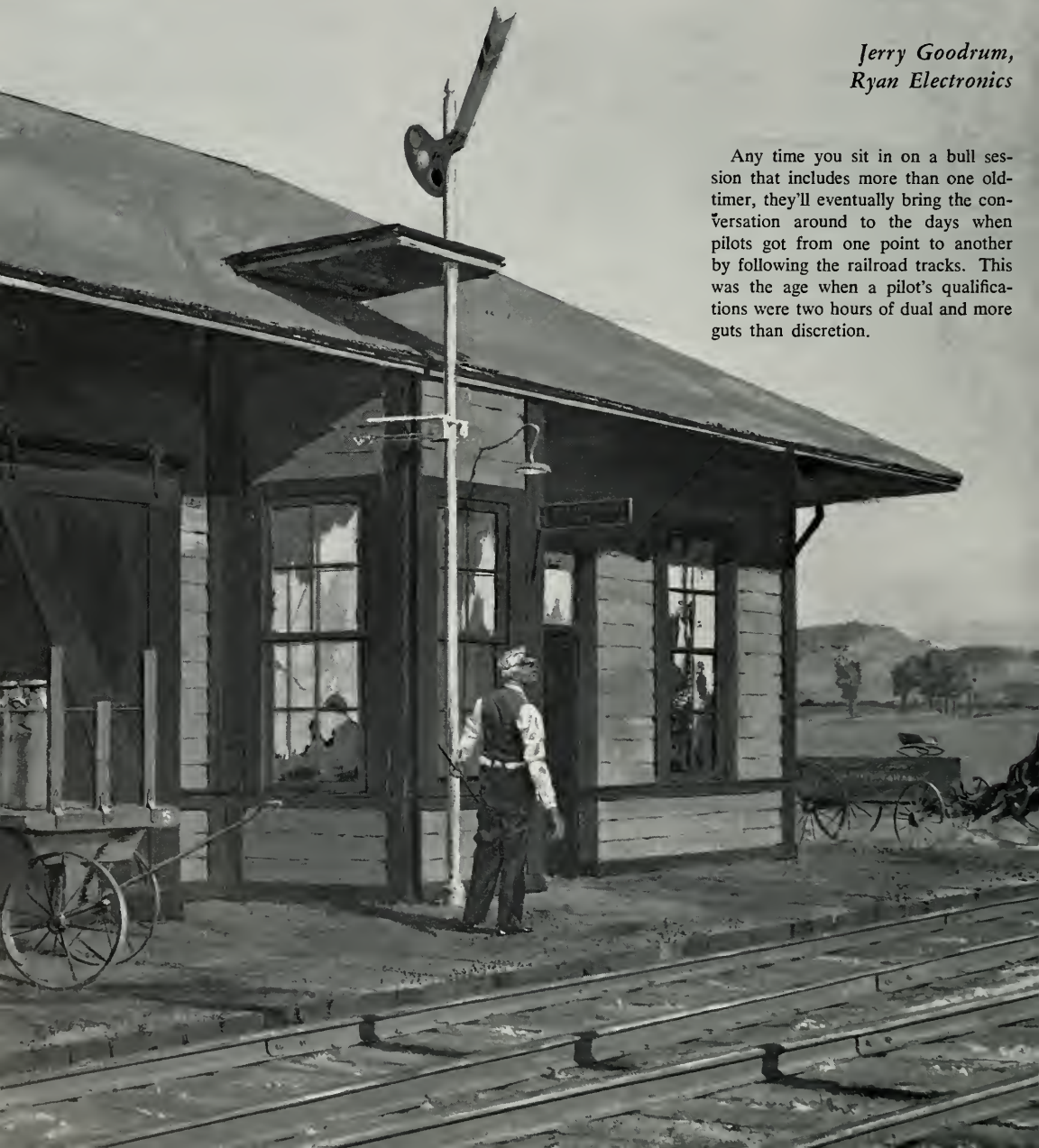
Another solid state device in current production at Ryan is a timer to initiate the release of the recovery parachute system in the Q-2C Firebees. Numerous other projects are in the development phase for applications in both the military and commercial areas, under the direction of Dr. C. M. Davis and Lewis Massie.

Ryan Electronics Sharpens the Eyes of Flight

IT SEES - IT REMEMBERS

Jerry Goodrum,
Ryan Electronics

Any time you sit in on a bull session that includes more than one old-timer, they'll eventually bring the conversation around to the days when pilots got from one point to another by following the railroad tracks. This was the age when a pilot's qualifications were two hours of dual and more guts than discretion.



Subtract the inevitable coloring that the stories have gained in the aging process, and the early days of flying still sound like one of the greatest adventure periods in history — because they truly were. And more than a few innocent bystanders got the pants scared off them when a cross-country pilot tried to resolve his confusion by flying low over a railway station to read the name of the town painted on the depot.

In an era not too far removed from the crawling pace of the horse and buggy, it was okay to navigate by the rail method. But rails had a habit of disappearing under fog or low clouds. Too, the pilot, being as green at railroading as flying, sometimes got switched onto the wrong track.

Even though the more serious-minded second generation of flyers has made aviation one of the safest means of travel, accurate navigation remained a complicated procedure until the advent of the continuous-wave (CW) Doppler technique—one of the last steps in man's long quest for superiority over the birds. Ryan Electronics, under Navy sponsorship, pioneered in adapting the principles of CW Doppler radar to the solution of automatic navigation for aircraft. Ryan's work in this field began in 1947 and culminated, in 1957, with the disclosure of the Ryan AN/APN-67 for the Navy—the first successful CW Doppler radar navigator.

In addition to being accurate and fast, this equipment is the lightest,

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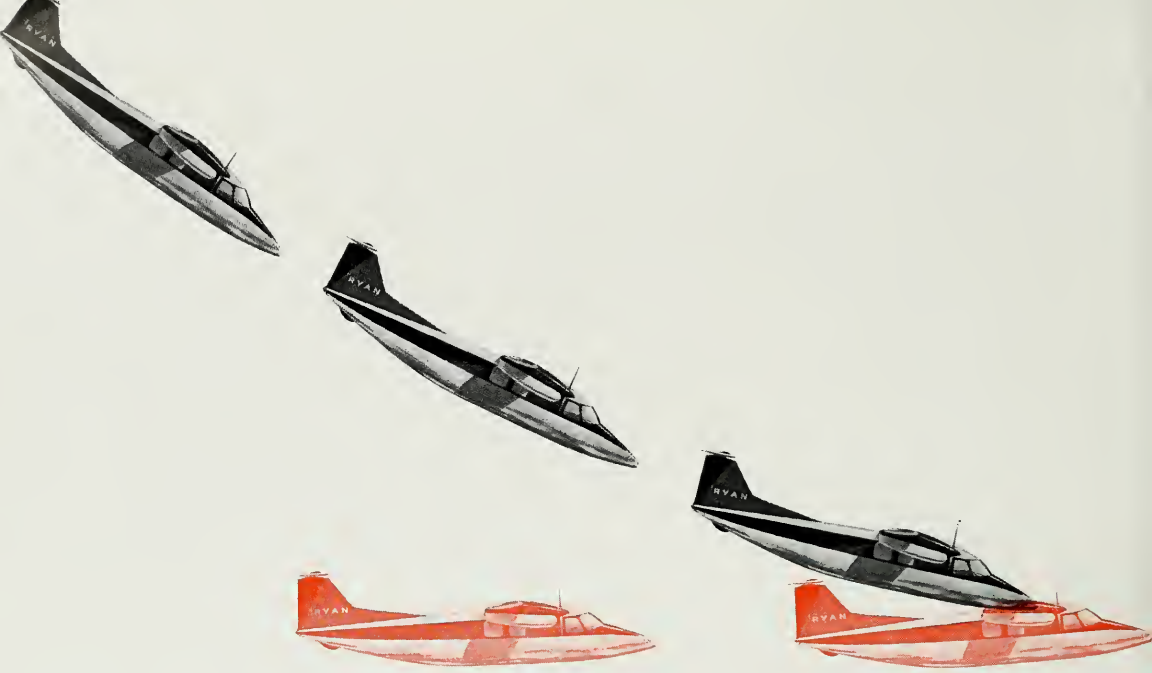


BOUNDARY LAYER CONTROL

RYAN CRASHES THE "RUNWAY BARRIER" ON TWO FRONTS

Extremely short take-off and landing runs may be achieved by high performance aircraft as a result of the work in boundary layer control which Ryan engineers are pursuing under a contract from the Office of Naval Research. George Farmer, Project Engineer and Fred Wagner, internationally-known aerodynamicist, are heading a group of Ryan engineers who are developing specific methods for applying the advantages of boundary layer control to aircraft.

For the Office of Naval Research, Ryan has completed two phases of a three-phase contract in which all available BLC data has been gathered and correlated and extensive wind and smoke tunnel tests have been completed.

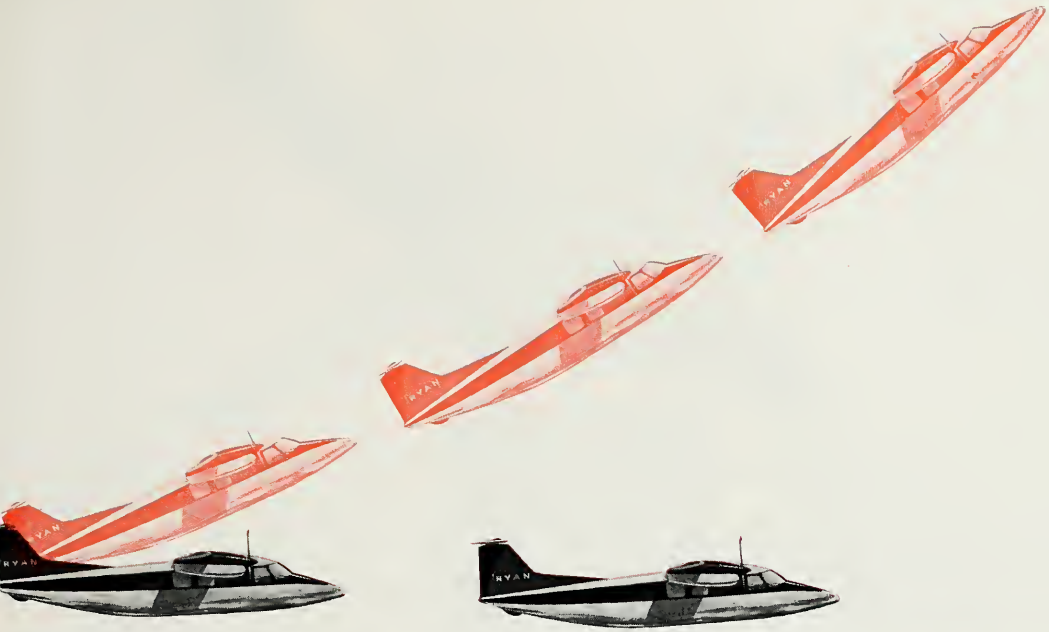
Under a company-sponsored project, Ryan has completed the preliminary design of a new aircraft—the Ryan BLC-7—which will employ a unique new system for gaining maximum advantage from boundary layer control. This high-wing aircraft will accommodate a pilot and six passengers and have twin-engine reliability. It will have true short-field capabilities which will meet or surpass existing non-STOL (short take-off and landing) aircraft in cruise and top speed and exceed them in economy and safety.

Conceived as a pioneering project, the BLC-7 project was transferred to the Aerospace Division for continued development. From its inception, the BLC-7 is being designed to take maximum advantage of boundary layer control—a "must" if unwelcome compromises are to be avoided.

To achieve optimum design in an aircraft, Ryan engineers consider three factors as a measure of effectiveness: (1) Operational adaptability—the airplane must do the job required in the environment of its use, (2) technical feasibility—performance and lift achieved through special devices must be within the current state of the art and (3) economic compatibility—the vehicle must be economically compatible with other modes of transportation.

The STOL concept is the approach within the present realm of technical capabilities that fulfills this requirement in a balanced design. Further studies show that the technology for STOL application is available today in the use of boundary layer control.

For many years it has been known that the thin envelope of air that sheathes the wing in flight, the "boundary layer", is of prime importance in



the maintenance of lift of the wing and in determining the aircraft's minimum take-off and landing speeds. Control of this layer, to prevent separation of the air flow over the wing, can greatly enhance wing lift and reduce flying speed for take-offs and landings.

Many methods have been tried, over the years, to maintain the integrity of the boundary layer. Suction has been used on the upper surface of the wing, to retain laminar flow. Air has been blown over the surface of the foil to achieve the same purpose. In 1942, Fred Wagner, now with Ryan, worked with the German Goettingen research firm to develop a successful jet pump BLC system for the Arado 232 troop transport. However, most of these endeavors either did not fully utilize the advantages of BLC or required impractical power sacrifices.

Ryan studies show that the entire trailing edge of the wing can be deflected, with the inboard flaps and ailerons subjected to blowing, and the outboard flaps subjected to suction. This combined system of suction and blowing requires only a fraction of the

Suction slot, on Ryan BLC wing model, is pointed out by engineer Fred Wagner.

Designed for boundary layer control, the Ryan BLC-7 can combine good cruise performance with STOL capability.

pumping power needed to drive an all-suction or all-blowing system for a given lift coefficient.

The Ryan BLC system is simple, compact, light in weight and reliable. It thus avoids the complications and unreliable machinery usually associated with BLC systems. Basically, it consists of jet pumps driven mainly by stored energy; multiple ducts along the full span of the trailing edge of the wing; and the operation of combined suction and blowing. The system is operated by independent power sources, each of which is able to sustain a safe emergency landing.

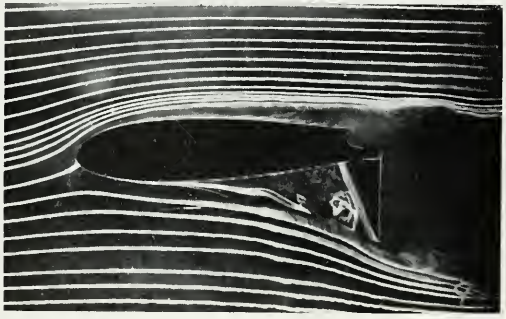
Under the smoke and wind tunnel tests recently completed, Ryan has studied the effects of BLC slot shapes, ground proximity effects, stability and control data for different power settings and other performance criteria. These data will be used to match pumping requirements to maximum lift results with semi-span wing sections in the wind tunnel.

Ryan investigations have shown the feasibility of the system which employs improved BLC air foils with an efficient, yet simple, duct-jet-pump arrangement driven by a plenum chamber type storage tank. The Ryan BLC-7 airplane achieves high lift on very small, highly loaded wings and thus avoids the high drag associated with low-loaded wings of most STOL aircraft. At the same time, clean design and high wing loading allow cruise speeds in excess of conventional transports of comparable power loading.

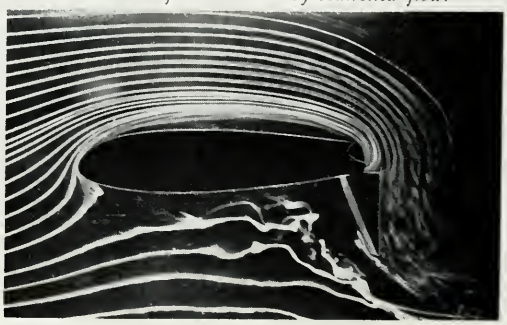
Perhaps the most attractive feature of the Ryan system is the certainty it offers for safe landing (at somewhat higher speeds) even in the event of a complete power failure of the main propulsion engines. The air reservoir of the BLC-7 contains enough energy to provide 4 minutes of full BLC operation even with both engines inoperative. Thus, if the aircraft is in jeopardy, the pilot can establish proper air speed and glide path and, for the final 4 minutes of his approach, use full BLC to obtain high lift, deceleration and a safe, much-reduced landing speed.

The BLC-7 is an appropriate aircraft to pioneer in the STOL environment. It is large enough for a transport system development and yet small enough for easy, economical fabrication. It is believed that the development of such an aircraft will play a prominent role in the future evolution of aviation — much as the DC-3 did many years ago. Behind this development, Ryan is placing an extensive experience in vertical flight, of more than two and a quarter million manhours of engineering devoted to the Ryan X-13 Vertijet and VZ-3RY Vertiplane programs.

Smoke tunnel tests show Ryan BLC wing with suction off.



With suction on, lift is increased by controlled flow.



Akers' Dozen . . .

(Continued from Page 12)

the threat of death, but where there is a difficult job to be done, a dangerous challenge to be met, you will always find men like these, men like 'Akers' dozen'.

Who, specifically are they?

Well, there is "Bud" Miller, number two man, aggressive, shrewd, intense.

Tall, thin, steel nerved Lee Boswell, boss of the pad.

Harley Eastman, hot shot instrumentation man, veteran of many a field operation.

Bill Meyers—slight, ruddy, with a high forehead; final checkout expert.

Crew cut Tommy Caldwell, with his deft, competent way with explosive fuses.

Coy Himebaugh, "the best flight test mechanic in the world," according to his teammates.

Slight, lean Lloyd Morrison, with an artist's ear for an engine's song.

Kenny McCracken. If you guessed that he could do about twice as much as anyone else and do it well, you'd be right.

Take Jim Donahoo. You have to see and hear him to believe him. He's a trouble shooter from A to Z, and his stories, if printable, would be best sellers.

Bespectacled Estanislao B a c a — short, dark, crew cut. A wizard at weights and balances.

Warren Krom — s a f e t y , engine check, inspection man with deepset eyes, and iron grey hair, and wearing a look of quiet competence.

Paul Tam — autopilot technician whose intense blue eyes look directly at you when he talks. You feel that he knows what he's talking about.

Head man Art Akers is a top field leader. He would be a good combat leader in warfare and he's a plenty good field tactician where he is.

These are the men; this is Akers' dozen. Capable, aggressive, reliable, sure of themselves. Ready to tackle difficulty and hardship with a grin. The kind of men Ryan assigns to the tough jobs, at White Sands, Holloman, Point Mugu. West to Okinawa, North to the RCAF at Cold Lake in Canada, South and East to Puerto Rico.

The next job might be anywhere; but these are the kind of men Ryan sends out with its equipment, the kind of team that over the years, since the birth of aviation has caused "Ryan" and "Reliability" to be synonymous in our industry.

CHIEF ENGINEER

William T. Immenschuh, formerly Executive Engineer of the Ryan Aerospace Division, San Diego, has been appointed Chief Engineer of the Division.

Immenschuh has been with the Ryan organization for more than 20 years, during which he has participated in design and development project engineering as well as in administrative capacities.

As Chief of Test Operations, he was closely associated with the flight testing of the world's first pure jet VTOL aircraft, the Ryan X-13 Vertijet, for the Air Force, and with other important test projects.

His two decades at Ryan have encompassed all of the company's major programs, ranging from the PT-21 trainer planes through the X-13, the VZ-3RY Vertiplane and the Firebee target missiles.

Immenschuh is a member of the Institute of Aeronautical Sciences, Society of Automotive Engineers, Association of the U. S. Army and National Management Association.

Flex Wing

(Continued from Page 4)

most obvious advantages of the flexible wing. The simple, inexpensive lightweight construction allows more effective wing area per-unit-weight than a conventional wing, resulting in greater lift for a given wing weight.

A wide variety of materials can be used for the flexible membrane. For low speed applications, the plastic coated nylon is adequate. For high speed, high temperature applications, more advanced materials, such as fine mesh wire cloth may be used. The side members and keel may consist either of rigid tubes or rods, or of collapsible tubing which could be inflated to give the desired rigidity.

Typical applications may include utility aircraft, towed gliders, equipment and personnel delivery vehicles, logistics delivery systems, weapons delivery systems, atmospheric recovery systems, space recovery and re-entry systems, reconnaissance vehicles, and as emergency wings for use with V/STOL (vertical and short take-off and landing) aircraft.

In systems employing an initial ballistic trajectory, followed by a gradual aerodynamic lift-drag atmosphere reentry phase, the flexible wing can be stowed in a thin tubular housing during the powered and midcourse flight phases. When deployed at an appropriate point of the trajectory, it provides the aerodynamic lift surface for reentry into the atmosphere at decelerated velocities which avoid many temperature problems.

In low speed manned and unmanned applications, the flexible wing offers a larger lift surface per unit weight than the conventional parachute, and provides a superior capability for trajectory control.

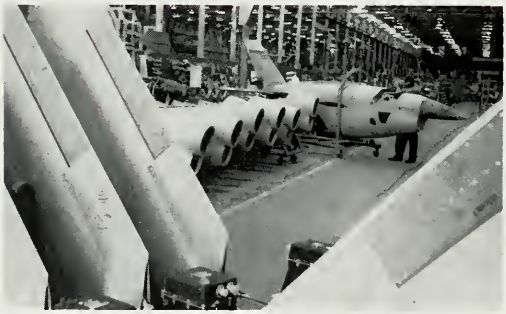
As a drone, its simplicity and light weight permits the flexible wing to be operated at the battalion level for surveillance, carrying photographic, television or facsimile equipment handled by a two-man team.

The low stall speed of the flexible wing vehicle expedites recovery of drones within a confined area, either on the ground or aboard ships.

1960 RECORD YEAR

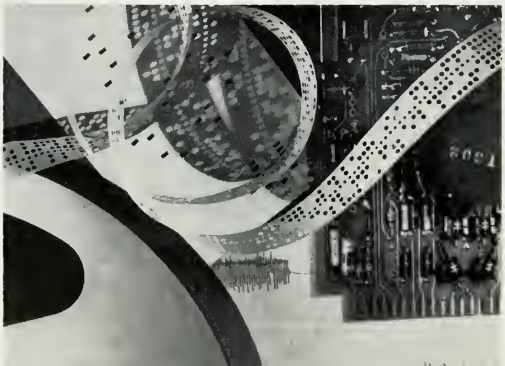
RYAN BUSINESS VOLUME

Electronic products hit $38 million — a nine-fold rise.



Advanced Firebees were delivered to Air Force and Navy.

New concepts in data retrieval developed for management.



An all-time high of $122,711,095 in sales for fiscal year 1960 were disclosed, recently, with the release of Ryan's annual report. This was a 45 percent increase in business volume over the previous year. Much of this 38-million dollar increase was accounted for by record prime contract sales in electronic navigational systems. Earnings of $2,894,055 for the year were also at a record level.

During the year, the company diversified its operations, to meet the space age challenge, by increasing its scientific and technical staffs. These outstanding personnel have given Ryan an advanced capability in electronics, space vehicles, missiles, communications and new propulsion systems. Added to the company's extensive experience, these additions provide facilities for complete systems management business.

The company is projecting new concepts of aircraft, including participation in a utility V/STOL (vertical and short take-off and landing) transport program, new Flexible Wing concepts with remarkably wide range of applications, and Boundary Layer Control studies.

The report disclosed that Ryan is entering into a joint-venture, with two other major companies which are leaders in certain other phases of aircraft design, in a new competition in the V/STOL field sponsored by the Air Force, Navy and Army.

Built in the Ryan main plant at San Diego is an experimental flexible wing research plane for a program which holds great promise for numerous future uses. The Army Transportation Corps has funded a flight test program of the test bed vehicle to yield data for various flexible wing applications. Other contracts have been received from the National Aeronautics and Space Administration for engineering studies of a prototype capable of recovering the Saturn first-stage booster; and from one of the military services for prototype drone vehicles.

In cooperation with a foreign company, Ryan is expected to launch advanced work in a new field, that of Boundary Layer Control, adaptable to many types of aircraft as a principle of short take-offs and landings.

The Electronics Division has unveiled a very advanced continuous wave Doppler automatic navigation set, "Ryanav IV", which combines improved performance with lighter weight and more compact size than the successful Ryan

T ALL-TIME HIGH

devices now employed in military fixed wing aircraft, helicopters and airships.

Techniques required for landings on the moon, and for recovery of rocket boosters from space, are under investigation by the company's Advanced Design section, which also is studying two complete missile systems.

A newly established Astronics Department, staffed by top specialists in high-resolution radar, is studying advanced detection, identification, reconnaissance, mapping, guidance and navigation systems in space environments.

Solar energy concentrators for use in outer space are being developed, as are various concepts for a permanent lunar base.

New explosive forming methods for producing extremely large missile components applicable to the Saturn booster vehicle are being used under contract with NASA.

Ryan Electronics is building a radar altimeter which will signal release from a larger spacecraft of the lunar capsule to be used in NASA's Ranger project. The Electronics Division also is seeking solutions to such other space system problems as rendezvous terminal guidance, anti-satellite terminal guidance, and communications antennas.

A newly created Avionics Department made great strides during 1960 in solid state physics and miniaturization techniques, including development of the Ryan "Minidine" static inverters used in wide band magnetic tape systems as an efficient frequency changer.

New operating techniques and still more advanced versions of the famed Ryan Firebee jet target missiles are being developed.

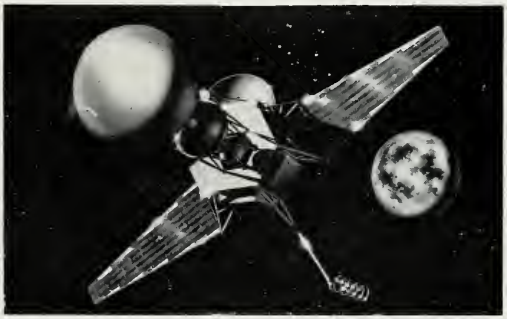
During 1960, Ryan launched an unprecedented rocket shot, the NASA "NERV" project in which a nuclear emulsion recovery vehicle was boosted to 1,200 miles altitude and a distance of 1,200 miles to sea, in a study of the lower Van Allen radiation belt. Other rocket vehicles are being prepared for high-speed re-entry research and for launching of high-intensity flares at more than 1,000 miles above the earth's surface to test a new surveying technique.

Substantial quantities of huge aft fuselages, for Boeing KC-135 jet tanker-transports, jet engine pods and pylons, for Douglas DC-8 jetliners and various engine components and equipment were delivered during the year.

Record rockets launched.

New V/STOL flight concepts.

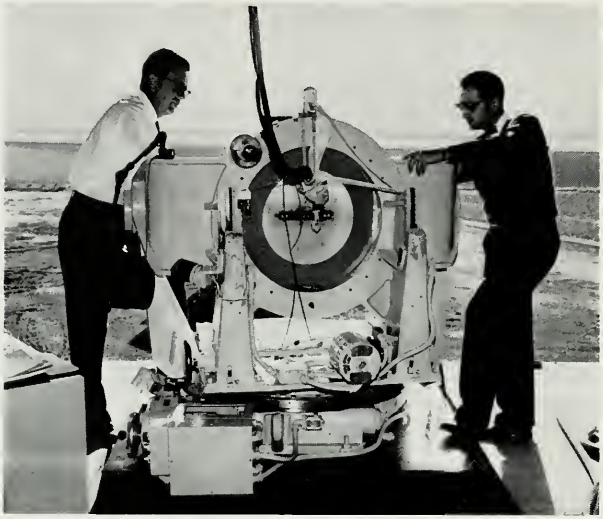
Solar energy reflectors and space structures developed.



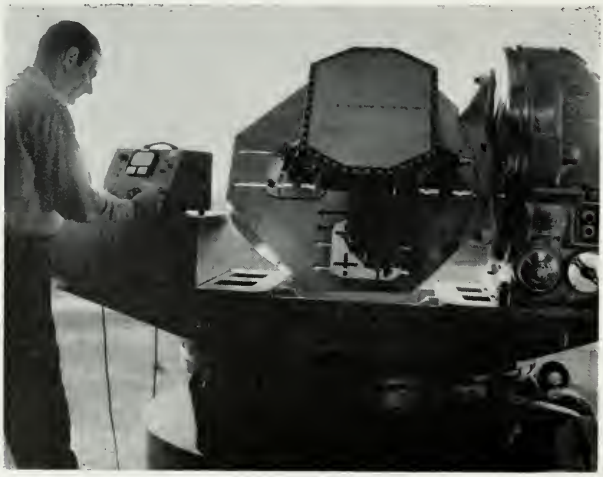
Lunar landing electronic altimeter for Project Ranger.

New products in solid state physics from Ryan Aerospace.

New Electronics Facilities



A major advance in antenna beam angle accuracy has been achieved with the installation of new boresighting mechanisms in the primary boresighting towers at both the Torrance, Calif. plant (photo above) and the Engineering Center facility of Ryan Electronics at San Diego (photo below). Ryan engineers have successfully integrated vertically and horizontally rotating tables designed to reduce beam angle error to less than five seconds of an arc. For comparison, the angle subtended by a ping pong ball at a distance of one mile is 3.6 seconds of arc. These precision tables replace gimbals which were formerly used to measure beam angles of precision antenna used in Ryan automatic navigational systems.



EVERINGHAM ELEVATED

Lloyd R. Everingham, formerly General Manager of Aerolab, has been appointed Director of Technical Operations on the Corporate Staff of the Ryan Aeronautical Company, reporting directly to R. C. Jackson, Executive Vice President.

A noted research scientist, Everingham will assist in the definition of Ryan's technical objectives and in coordinating the capabilities of the divisions. Prior to joining Aerolab, Everingham was Vice President in charge of research at Radiation, Inc., and was also associated, for many years, with Cornell University's Aeronautical Laboratory as a member of the management and scientific staff.

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Flex Wing Contracts

(Continued from Page 5)

ing terrain and gathering other combat intelligence.

Capable of being launched from unprepared sites, by a two-man team, the flexible wing drone can be radio controlled and recovered by landing on skids at low velocity. It could carry photographic or television equipment for observing conditions over a wide area.

Data For Decisions

(Continued from Page 7)

center must be staffed by highly competent personnel since system effectiveness is a direct function of the ease and accuracy of data retrieval and this is in turn controlled by the thoroughness of indexing and cross-referencing. Handling of the data within the central may be on random basis and each bit of data may pass through one or more stations.

The stenographic pool converts dictation to digital data, sorts incoming mail, inserts multipage documents into handling containers and other similar tasks.

The programmer and monitor unit schedules the computer to prepare routine reports, such as work status, machine efficiency, spare parts lists, material shortage lists, schedules, profit and loss statements, etc., runs purging programs through the files to remove obsolete material, reviews purged data prior to dump, and monitors overall system performance.

The holding station is used to hold forced data (data which is automatically presented to a station without that station requesting it) until the addressee acknowledges receipt of data. In the case of priority messages, the sender is notified automatically if this message is not delivered in a pre-established time.

The abstract preparation unit will ultimately be completely mechanized; however, until approximately 1965 this will be a manual operation. The object is to prepare brief abstracts of multipage documents. The abstract is then stored in magnetic store and the complete document goes to library document storage.

Library document storage contains three classes of documents: reference works, technical reports and catalogues. The reference works are retained permanently, the technical reports are retained for a fixed period of time, then reviewed and if deemed to have continuing value, they are microfilmed and the original destroyed. If they have no further value, they are destroyed and the abstract is microfilmed and sent to historical section of the film file. Catalogues are automatically destroyed at the end of the fourth year on the assumption that a more recent edition is available.

The data processor is a standard digital computer selected to handle the computation load of the company, plus the preparation of special management control data and servicing of the storage and index units. The magnetic storage is in two forms—one is a video file using conventional video tape for storage of facsimile and digital data—the other is a very large capacity rapid access digital data store, used for accumulation of data during processing steps for servicing of printout and display equipment.

All permanent data is retained in the magnetic store for an initial period, usually one month. At the end of this time, it is transferred to the film storage for long term storage. Transient data such as current position of work in progress is dumped at the end of its use period.

The film storage unit records data on aperture cards (punched cards containing a frame of microfilm) for long term storage. When retrieved for use, the cards are scanned by facsimile equipment and the card itself never leaves the file area.

The master index is a large capacity random access magnetic store and logic unit. All data available to the output system is cross-indexed in this file and upon a specific request a list of the documents most likely to supply the information desired is presented on the requestors display; he then enters requests for any of the documents he desires from the lists.

The output unit supplies external output in the forms of letters, telegrams and facsimile messages. Internal outputs are in the forms of desk or wall displays and hard copy facsimile printers. Data sanctity and privacy is controlled through authority codes which will only accept requests for sensitive data from stations authorized to receive it.

The system outlined is within the state-of-the-art today. The problem facing any effort such as mine in trying to sell such a system is that it is difficult to prove the potential savings in terms acceptable to a controller. The cost however, must be stated in cold, hard terms and, as you can gather from the equipment involved, the first cost is high. This condition will slow down growth, but will not stop it.

In 1950, the computer industry was simply a novelty—today it's a giant—by 1975, the computer industry will merely be a segment of the broader information systems business. Transmission of data over communications lines will exceed their use for conversation. Those of you who have teenage daughters may not agree with that last statement.

Accomplishments in this field are not as glamorous as the launching of the first Atlas, the maiden flight of the 880, or the ground launch of the Firebee Jet Target System; but the long range impact will overshadow these.

Transdata's Josh Gershuny (left) confers with Richard Stine in development lab.

It Sees, It Remembers

(Continued from Page 17)

simplest and most compact navigational system available. It permits the pilot to fly anywhere in the world, regardless of the weather and without benefit of ground stations, wind estimates or true air speed data.

Such a significant achievement was not accomplished overnight. Christian Doppler, an Austrian physicist, first formalized the principle of frequency shift, now known as the "Doppler effect", in 1842. The initial research for application of the phenomenon to aerial navigation was begun in 1933 by the Naval Research Laboratory, Washington, D.C. Ryan Electronics developed it to the present state-of-the-art—a whole family of Doppler radar navigation sets providing accurate, instantaneous navigational information that is ideal for almost any type of aircraft or mission.

The extreme accuracy of Doppler navigation is perhaps its biggest contribution to aviation safety. These sets, for instance, have demonstrated accuracy to better than ½ of 1% of the distance traveled. They maintain that accuracy through a wide range of aircraft altitudes, and from 0 to 70,000 feet, automatically and continuously providing groundspeed and drift angle information as well as other vital navigational data to the pilot. Continuous-wave Doppler, as opposed to pulse or other modulation techniques, starts operating while the aircraft is still on the runway and continues to function throughout the flight, even including the extreme attitudes of terminal maneuvers, until the plane is back on the runway again.

Continuous-wave radar systems can transmit and receive energy simultaneously and continuously. However, the pulse-type radars cannot. The latter must transmit radar energy in short "bursts," then stop to "hear" the returning echoes; while the CW systems receive data 100% of the time, contributing to highest accuracy.

No small safety feature of the Doppler navigator is the fact that it eliminates the need for many of the instruments now used in conventional navigation, and being completely automatic it leaves the pilot and navigator free to concentrate on other problems. Doppler sets are extremely simple to operate. As any pilot knows, the more duties he has in the cockpit the more chances he has to make mistakes.

These and other features of Doppler navigation provide a degree of safety in aviation that formerly was achieved only through an elaborate, expensive network of ground radio transmitters and beacons. Such a network obviously cannot be built to cover the entire globe. Outside of the networks, the flyer must resort to dead reckoning and celestial methods which at best can tell him only approximately where he was when he began his computations. This might have sufficed in the slow-moving aircraft of WW II vintage, but is hardly adequate for modern high performance aircraft rapidly moving toward the Mach 3 range of operation.

Too, the cold war has made the aviation world acutely aware of the vulnerability of ground stations to jamming. In the event of war, these facilities undoubtedly would be silenced—in friendly as well as enemy countries. With the completely self-contained system of automatic, instantaneous navigation which Doppler provides, these problems are eliminated. A self-contained system is impervious to jamming.

When transports begin to operate at Mach 3, the pilot not only will have to know his precise position at all times in order to stay in the proper air lane, but he will have to know exactly where his plane will be at any given moment in the future of the flight, or America's air transport system could become a national tragedy instead of a source of pride. With the Doppler technique, the problem is solved before it arises.

Doppler, of course, was developed for military applications and, because of its long term accuracy, has been especially beneficial to far-ranging bombers. But a couple of side benefits were discovered after its development: because Doppler eliminates the requirement for wind information, dangerous straight and level wind runs preceding the bombing run no longer are necessary. And when Doppler is tied into a bomb directing set, it permits the pilot to take evasive action right up to the target because the navigational information needed for bombing computations is instantaneous and automatic. The pilot is left free to protect his aircraft and the bombardier-navigator is free to concentrate on the bombing problem. For helicopters, Ryan Electronics achieved an important breakthrough by perfecting the first navigational system which provides helicopters with all-weather capability for accurate hovering, navigation and programmed flight. The only Doppler helicopter navigational set in worldwide use, Ryan equipment is in full production for the Navy, Marines and Coast Guard and the British Navy. Applications for the Ryan AN/APN-97 and AN/APN-130 include anti-submarine warfare, rescue, navigation, blind landings, automatic hovering, aerial service, drone helicopter control, reconnaissance and traffic control.

When Doppler is tied in with automatic stabilization equipment and an altimeter, the helicopter pilot can command a fully automatic maneuver from normal cruise conditions through transitions in both speed and altitude to a hover.

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The very nature of the helicopter makes this a factor for increased safety in almost any type of mission, and especially in rescue work where precision hovering may be the key to saving a life. Ryan engineers say their automatic helicopter sets provide more precise, sustained hovering control than the best pilot can accomplish manually under the most ideal conditions.

In helicopters, as well as in fixed-wing aircraft, Doppler sets with computer tie-in can "remember" a course just flown and use the information to permit the aircraft to automatically retrace its route. Almost any experienced pilot can recall situations in which he would have swapped all his knowledge of navigation for just such a device.

Measurement of the frequency shift of microwave energy is the basic principle of Doppler navigation. The

energy generated by the set is concentrated into two or more narrow beams and directed by an antenna in the aircraft toward the terrain below. The aircraft's motion causes a difference in the frequencies of the transmitted energy and the energy which the terrain reflects back to the antenna. The difference is directly proportional to the speed of the aircraft.

With one microwave beam, only one component of the aircraft's speed can be measured. But with two beams of radiation and barometric altitude rate data, it is possible to compute the aircraft's heading speed, drift speed, ground speed, and drift angle. Additional beams can be included to meet the special requirements of helicopters and airships. Doppler sets which provide navigation without reference to wind data actually can automatically compute and display wind speed and direction by combining groundspeed and true airspeed information.

The ground velocity data obtained with the Doppler set is the basic output from which other vital navigational data is generated. It can be directly integrated to provide ground miles, or it may be used in a navigational computer, along with true heading information, to determine the north-south and east-west components of the aircraft's velocity.

This velocity data can be automatically integrated to obtain north-south and east-west distances traveled, which in turn can be converted to latitude and longitude coordinates. Knowing the present position and the desired destination, the best course and shortest distance to that destination can be automatically computed and displayed.

Reprinted from Aerospace Safety Magazine, Deputy Inspector General for Safety, U.S. Air Force.

FIREBEES WILL BE "ENEMY FLEET" AT WM. TELL 1961

Ryan Q-2C Firebees have again been given the top assignment in Air Force marksmanship competition—to serve as jet targets for "William Tell 1961," the ninth World Wide Weapons Meet, scheduled Oct. 16-26 at Tyndall Air Force Base, Fla.

It is anticipated that 110 Firebees will be furnished to provide a realistic challenge to Air Defense fighter-interceptor crews flying Convair F-102 Delta Daggers, Convair F-106 Delta Darts, and McDonnell F-101B Voodoos firing guided missiles.

The free-flying Ryan Firebees were prime targets in the "William Tell" air-to-air missile meets at Tyndall AFB in 1958 and 1959, when their reliability under even the most adverse weather conditions was hailed by officers who described the competitions as the most successful events of their kind ever conducted by the Air Force.

Also for the first time, Firebees will be ground-launched as well as air-launched. Ground launch capability is being "built into" Q-2C's on the Ryan-San Diego assembly lines.

The Q-2C will be the highest performance Firebee ever entered in the "William Tell" meets, capable of flying faster and higher than its Q-2A predecessor used previously.

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ON THE COVER

Ryan Flex Wing is launched by Army's Maj. Gen. Richard D. Meyer, Chief of Transportation Research Command, at Los Angeles Biltmore, March 8, 1961.

Please send address changes to:
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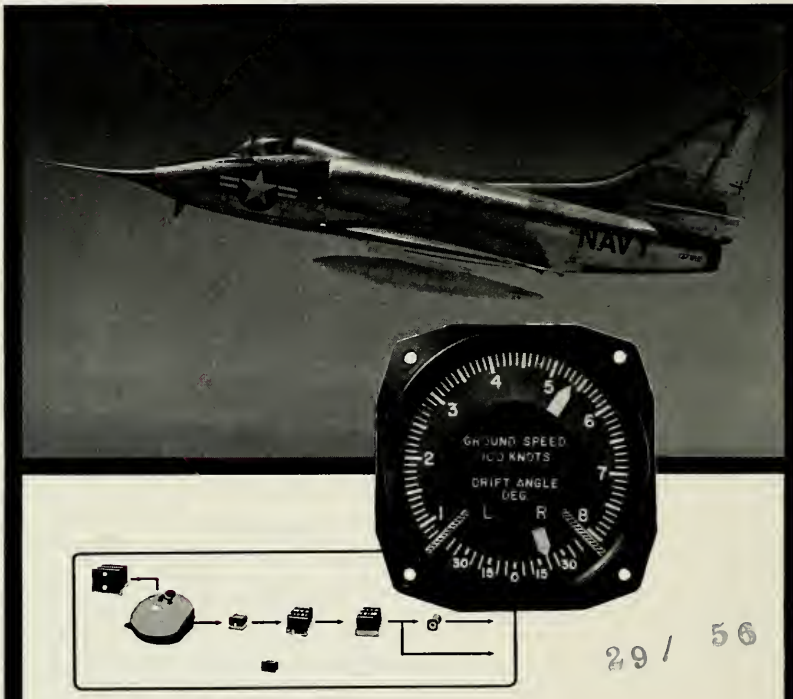

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WHY THE RYAN APN-122(V) GROUND VELOCITY INDICATOR IS THE FINEST, MOST WIDELY USED DOPPLER NAVIGATOR IN THE WORLD

Adaptable for nearly every type of aircraft, the Ryan APN-122(V) continuous wave Doppler system provides instantaneous and continuous display of ground speed and drift angle *in all weather* without reliance on ground or celestial aids. Here are some of the advantages that make this Ryan radar system the most advanced, *proven* means of aerial navigation.

- Ryan APN-122(V) is **qualified**, thoroughly **proven** in flight and **in full production.**
- Meets MIL-T-5422D and MIL-E-5400C specifications.
- Has no altitude or attitude holes.
- High accuracy (within ½%) at all altitudes from 0 to 70,000 feet, and over seas even smoother than Beaufort 1.
- No minimum altitude. Operates during take-offs, landings and turns.
- Operates in the **approved** frequency range (13.25-13.40 kmc/s).
- Speed ranges: 80-1000 knots; and 120-1600 knots.
- Fixed (non-gimballing) antenna.
- Outputs suitable for damping inertial sets.

APPLICATIONS OF RYAN APN-122(V) NAVIGATOR

ANTI-SUBMARINE WARFARE • PRECISION BOMBING • GENERAL NAVIGATION
RECONNAISSANCE • AERIAL PHOTOGRAPHY • AERIAL SURVEYS • AEROLOGY
AIRBORNE EARLY WARNING • RADAR STABILIZATION • INERTIAL DAMPING

AIRCRAFT ALREADY USING RYAN APN-122(V) NAVIGATOR

A2F W2F

R5D

P5M

P3V

A4D

S2F

A3D

P2V

WV-2E

RYAN REPORTER

"I FLY THE FLEX WING"

VOL. 22, NO. 2

I FLY THE

THERE had never been an aircraft resembling it. In an era of missiles, rockets, space vehicles, supersonic fighters and bombers, this strange-appearing creation seemed incongruous. But when I sat on the "Flex Wing" platform for the first time, I experienced the sensation of initial discovery which must have gripped the Wright Brothers, Glenn Curtiss and the other pioneers of flight.

For despite its deceptively primitive appearance, here was a vehicle geared to the Space Age — an adaptation of ancient principles to such 20th century applications as high altitude recovery of rocket boosters, space craft re-entry, remote controlled reconnaissance drones, and helicopter-towed gliders to carry troops, cargo or fuel.

This was Leonardo de Vinci brought up to date by Francis M. Rogallo, National Aeronautics and Space Administration scientist, whose flexible wing concept so intrigued Ryan that a test bed was designed by our Aerospace engineers and manufactured in the company's main plant at Lindbergh Field, San Diego.

Rogallo had investigated the flexible wing's unique characteristics through wind tunnel and unmanned model studies and tests at NASA's Langley Research Center. Now came the start of the payoff — full scale flights with the research test bed. With no precedent to draw from, this arrow-shaped, kite-like object was to provide the data available only from manned flight.

Hence that feeling of approaching an exciting new frontier when I examined the "Flex Wing" for the first time.

Seated in the open on a slab of aluminum suspended beneath a wing, produced by a sailmaker, I experienced the same sort of exhilaration Orville Wright must have felt when his crude craft leaped briefly from the earth.

The test bed of the "Flex Wing" utilizes such off-the-shelf items as a control wheel from a World War II bomber, a seat from an old light plane, and foot pedals from a more recent light plane.

The wing is Mylar bonded to nylon. It hangs loosely between an aluminum longitudinal keel and two tubular leading edges flexibly joined at the front end of the keel. The wing, with a span of approximately 40 feet, is much like a boat sail in that its lifting power is derived from the flow of air which inflates it.

Suspended beneath the wing is the open-frame body with a four-wheel landing gear. A 180 hp Lycoming engine is mounted at the aft end of the fuselage, behind the pilot. The entire

(Continued on Page 2)

EX WING

by Lou Everett, Project Engineer

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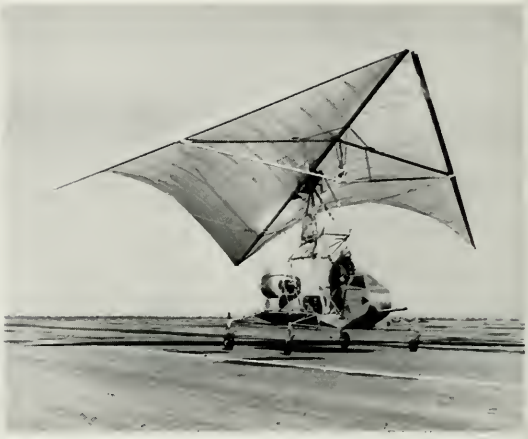
"Despite its primitive appearance, here was a vehicle geared to the Space Age—Leonardo da Vinci brought up-to-date by NASA."

The Ryan Flex Wing awaits runway clearance as a Navy jet takes off from Brown Field, Otay Mesa, Calif., scene of unique new craft's first flight.



The start of the payoff after wind tunnel and unmanned scale model studies — full scale flights with the research test bed.

machine weighs about 1,500 pounds, including instrumentation.

Among our first discoveries during the taxi runs was the need for relocating the wing pitch control pivot point. This is a critical feature, since the "Flex Wing's" control system functions without conventional hinged surfaces and flaps. The principle is the same as that used by the German glider pioneer, Otto Lilienthal, in the control of his hang gliders.

Lift and drag forces of the wing must pass through or close to the control pivot point in order to keep the control forces from being excessively high. Hence, proper location of the wing control pivot point as related to the wing itself is vital. The body of the "Flex Wing" swings from hinges between the pylon and the wing keel. I move the fuselage forward, backward or sideward relative to the wing by manipulating the control yoke. This moves the horizontal position of the center of gravity relative to the center of pressure on the wing, causing moments which make the wing seek a new angle.

(Continued on Page 29)

Test Pilot Lou Everett explains to Navy personnel at Brown Field how the controls contrast with conventional aircraft.

Top civilian officials in astronaut program, NASA's Robert Gilruth and Walter Williams, were intrigued by Flex Wing.

Engineers and technicians swarm around Flex Wing as Everett returns from another test flight with new performance data.

"I experienced the sensation of discovery that must have gripped the Wright Brothers, Glenn Curtiss and the other pioneers."

More than 300,000 visitors from nearly 30 nations thronged main exhibit hall and other display areas at Le Bourget Airport, Paris.

PARISIAN SHOWCASE

Ryan displays its products at world's biggest air show

U. S. Navy Sikorsky HSS-2 helicopter equipped with Ryan Doppler self-contained automatic navigation sets made many demonstration flights at Paris Air Show.

RYAN showcased its products at one of the most successful exhibits in the world's biggest air show, the 24th Salion International De L'Aeronautique at Le Bourget Airdrome, Paris, May 26 through June 4.

More than 300,000 scientists and engineers, and aerospace specialists representing nearly 30 nations were registered at the show, in addition to the millions of spectators from throughout France and surrounding countries who observed the various events, including two full days of spectacular flights and aerobatics.

The Ryan exhibit, designed to inform military officials and others in the aerospace field of this company's capabilities, was manned by five Ryanites—Eddie Sanders, Assistant to the Vice President-Operations; Don Fairchilds, Electronics Public Relations Manager; John Bowden, Electronics Chief of Advanced Design; Herbert H. Hauser, technical assistant to Bowden, and liaison for European affairs; and Alain Jourdan, a former Lt. Colonel in the French Air Force who is stationed in Ryan's Paris office.

Numerous active sales leads throughout Europe were generated by the display, and immediately after the show, Ryan "teams" visited several airframe manufacturers, principally on behalf of the Doppler navigators produced by Electronics.

In addition, the European press spotlighted the Firebee, Ryan's explosive forming techniques, the "Flex Wing," and Doppler navigators.

Two radio interviews, taped in the Ryan booth with Jourdan and Hauser,

were broadcast nationally in France.

The Ryan exhibit displayed complete production systems of the AN/-APN-97A navigator for helicopters, Doppler checkout and test equipment; samples of explosive forming, miniature and subminiature electronic components, and intricate machine parts such as wave guides.

In addition, the exhibit served as the public debut of the revolutionary new universal lightweight navigator Ryanav IV, first of its kind in the world. Ryanav IV meets the operational requirements of aircraft ranging from drones and helicopters to supersonic jets, and including VTOL and STOL aircraft.

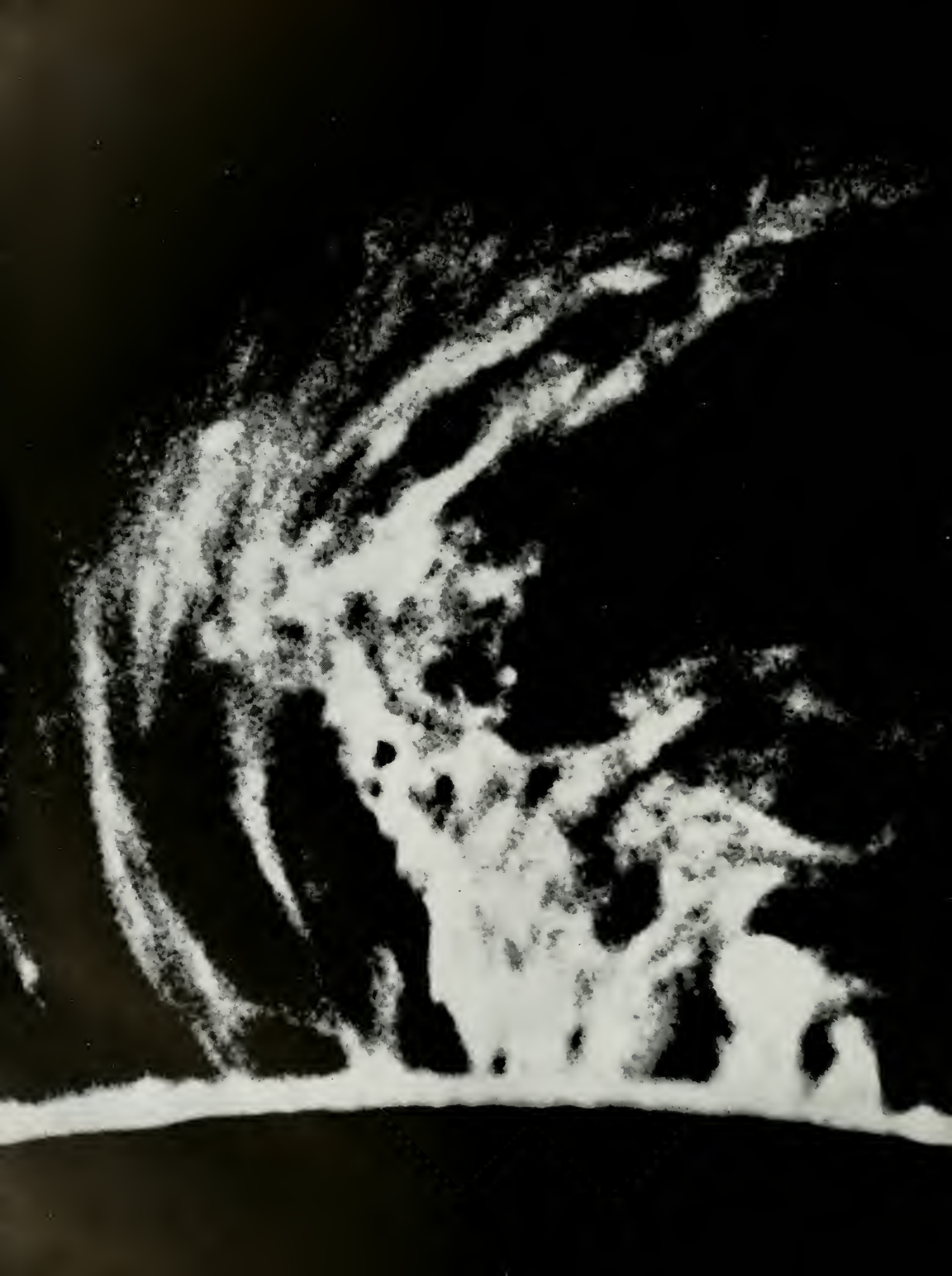
A "Spirit of St. Louis" theme in the exhibit captured the attention of visitors, as 5,000 models of Lindbergh's famed plane, built by Ryan Airlines in San Diego, were distributed to commemorate the 34th anniversary of his flight to Paris.

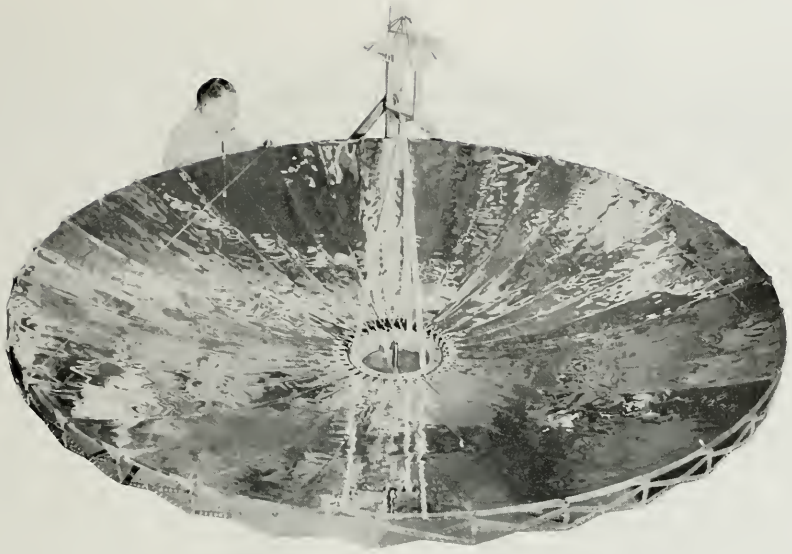
An illuminated revolving plastic sphere contained a "Spirit of St. Louis" model and three Firebees in formation.

Specially produced for the air show, an 8-minute continuous run color movie told, in alternating English and French narration, the exciting story of Ryan development of Doppler navigators and Firebees.

Ryan booth at Paris Air Show featured Doppler navigator equipment, samples of explosive forming, miniature electronic components, and intricate machine parts. Continuously shown was color movie story of navigators and Firebee targets.

Among Ryan Doppler navigator-equipped aircraft at Paris Air Show was Royal Navy's Westland Wessex anti-submarine helicopter.





"WAY OUT" MIRROR

RYAN engineers have joined the age-old quest for a means of capturing energy from the sun — the greatest known source of power in our solar system.

Adapting the fabrication and metallurgy know-how acquired in a long period of developing ultra-lightweight structures, Ryan Aerospace has entered the field of solar concentrators for space application through the construction of models of "way out" mirrors.

The first such full-fledged project was recently completed for a company, which currently is developing a large solar mechanical engine.

Continued research is being conducted to perfect techniques that will insure the extremely high degree of accuracy required in solar mirrors.

The unique mirror built by Ryan is a 10-foot diameter metal assembly, slightly less than one-fourth the size of

(Continued on Next Page)

ABOVE: Solar mirror quarter-scale model in deployed position as it is checked for parabaloid shape accuracy.

LEFT: Spectacular solar flare symbolizes energy which man will capture from sun to provide power for space vehicles.

An optical checking system was developed by Ryan to evaluate the slightest slope error in individual mirror blades as well as complete reflector assembly. Light beam is directed from above while technician at right uses transit to sight on target in focal plane.

the full-scale solar radiation concentrator envisioned for the 15-kw power system for space-vehicle applications.

Consisting of 36 blade sectors, the paraboloid is designed for folding during boost, and automatic deployment as soon as the orbit is established, to concentrate the sun's rays into the power package for engine operation.

When folded into position between the satellite payload and the power unit at launching, the concentrator would assume a cylindrical shape. In this configuration, the 10-foot model is 28½ inches in diameter and 56 inches long.

The novel deployment system permits packaging the reflector within the specified confines, supports, and synchronizes the separate mirror components during the deployment process, insures rigid support and accurate alignment of the deployed reflector, and permits re-folding of the assembly after ground checkout, if desired.

The 36 blades comprising the mirror are hinged at their inboard ends, with the hinge axis inclined so that the blades swing upward parallel to the axis of the parabola and rotate so that in the stowed position their tips are disposed radially.

Joints along the opposite edges of an expandable support ring are pulled together by an actuator cable extending the ring in "lazy tongs" fashion to effect and synchronize the deployment of the separate blades. Restraining guy wires are payed out as the actuator cables are reeled in. Stops, between each pair of upper and lower joints in the outer support ring, are finally pulled tightly together by the cable, forming a rigid stiffening flange around the outer periphery of the mirror.

When the blades are fully deployed, tension is applied to the annular cables. This has the effect of pulling adjacent blade edges tightly together against accurately located stops. Thus, the inherent double curvature of the paraboloid is utilized to provide rigidity and preserve contour accuracy.

Surface skin of the mirror blades is of polished, hard-rolled aluminum foil

of .005 inch thickness. In the forming of these skins, Ryan used its advanced new explosive forming methods (see Page 16), as well as other sheet metal forming techniques.

A plaster "master tool" was produced by sweeping a precision steel template around the axis of its parabolic contour. Prior to production of "second generation" tools, the surface contour of the master was optically checked to insure the critical accuracy required.

At each step of production, through tooling to fabrication of the individual mirror blades, the complete reflector assembly is checked optically. The checking system utilizes a vertical collimated light beam reflected back to a target in the focal plane to evaluate slope error.

A plaster assembly fixture and an epoxy-faced explosive forming die were cast, as negatives, against the surface of the master tool. These permitted forming and subsequent assembly of the mirror face skin with the reflecting side against the tools so that the rear side was accessible for attachment of the supporting structure.

A special "lattice truss" panel construction was developed as the backup structure for the aluminum face skin of the sectors. The mirror blade elements were fabricated by resistance welding of components made with a minimum of special tooling. The "lattice truss" arrangement permitted achievement of the weight goal without difficulty, and at the same time allowed sufficient panel thickness to provide good structural rigidity.

Other advantages offered by the "lattice truss" were:

1. Accurate conformation of the stiffening structure to the double curvature of the mirror surface.

2. Assembly from standardized components.

3. An open truss type panel structure that can be increased in depth to take advantage of available space in the full scale vehicle package. This can be accomplished in such a manner as to increase the spacing of the back face channels and actually reduce the panel weight, while simultaneously increasing its stiffness.

4. Adaptability to non-uniform loading conditions.

5. Open back structure permits radiation directly from the back of the mirror surface and minimizes thermal distortion.

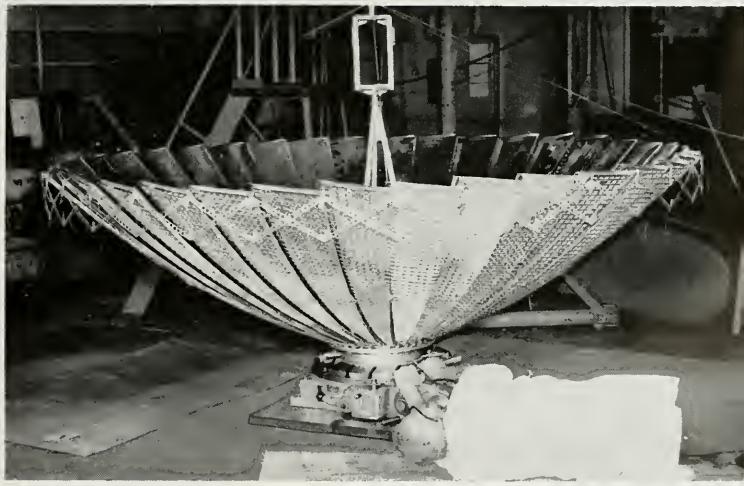
All-metal construction of the concentrator assembly has apparent inherent superior characteristics.

Doubts currently expressed regarding the resistance of organic materials to sublimation under the very low pressure of space environment are avoided in the use of metal. Since the fuel is "massless", but the solar power plant is heavy compared to other systems, solar power becomes attractive only where power is required for an extended period of time. Consequently, Ryan efforts have been directed toward solar concentrators with useful life expectancies of several years.

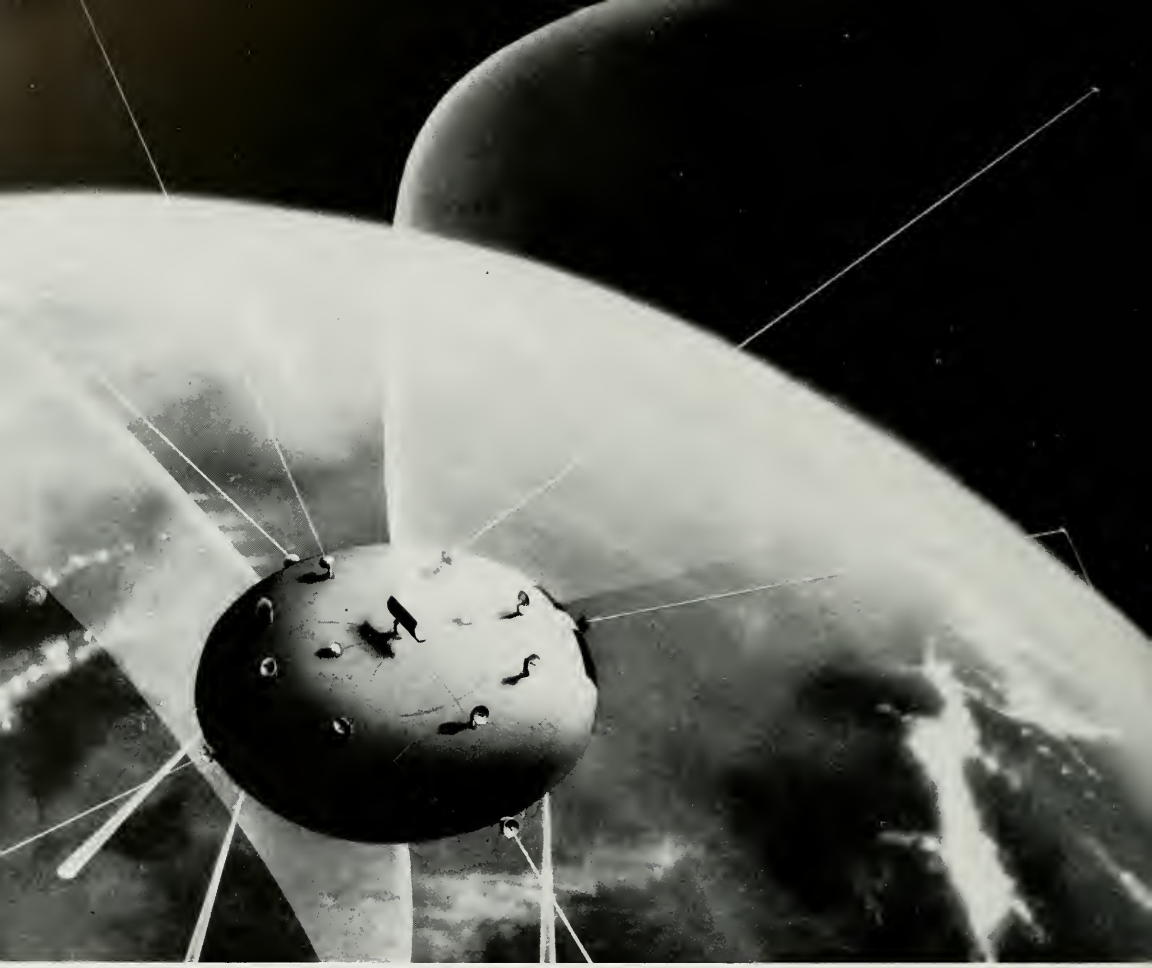
In addition, the rigid metal blades and deployment system utilized permit ground checkout testing of the system under atmospheric pressure and earth gravity conditions. Since deployment

(Continued on Page 26)

Solar mirror would be carried as compact folded "package" in launch and booster phase prior to deployment in space.



Ryan solar mirror model, shown partly deployed, consists of 36 blades given lightweight rigidity by a special "lattice truss" panel construction as the backup structure welded on aluminum face skin of the blades, which were shaped by explosive forming methods.



Orbiting patrol craft could warn against ICBM attack. The author outlines communications requirements of a future satellite fleet.

TRACKING ENEMY

by Maurice N. Kaplan, Senior Research Engineer

RYAN ELECTRONICS

THE earliest and most useful warnings of intercontinental ballistic missile attacks could be provided by spacecraft constantly moving in precisely defined orbits.

In event of an ICBM attack, a large number of target missiles might have to be tracked simultaneously while specific interceptors were being vectored to engage and destroy them in mid-trajectory without interrupting other vital communications carried over the satellite link.

Thus, optimum coordinated defenses against ICBM attacks are impossible without a spaceborne communication system having a reliable high-information-rate capability. What are the communication requirements of a future satellite fleet?

The ideal defense, while not feasible now, may become so some 10 to 20 years hence, depending upon the emphasis given to and the success derived as the result of presently projected basic and applied research. An interim defense, which could be highly effective, might be possible much sooner if an adequate communication capability could be provided for a currently feasible satellite fleet.

The communication aspects of the ideal defense ultimately desired and the interim defense just mentioned are virtually identical. Thus, the electronics systems research and development accomplished for initial uses in the interim defense, packaging excepted, could be easily adapted for subsequent use in the ideal defense.

Studies have shown that effective surveillance of the earth's surface area, on a full-time basis, at a practical operational altitude, will require a minimum of 72 spacecraft. For excellent reliability considerations, just twice this number, or 144 spacecraft, should be deployed into 12 squadrons of 12 spacecraft per squadron.

The spacecraft of any specified squadron would travel in tandem formation in precise, circular, essentially identical, coplanar orbits. The mean distance between spacecraft would roughly fall between 2,130 and 2,200 miles for orbital altitudes varying between 100 and 220 miles. The 12 squadrons would be stacked at intervals of about 5 miles or more to eliminate the possibility of collisions between craft passing over earth's north and south geographic poles or between counterorbiting squadrons.

Each vehicle would have a specified pitch, yaw, and roll axis. The roll axis of any vehicle would be aligned parallel to the orbital velocity vector, and the pitch axis of any vehicle would be aligned normal to the orbital plane. This would give familiar meanings to concepts of up, down, left, right, ahead, and behind.

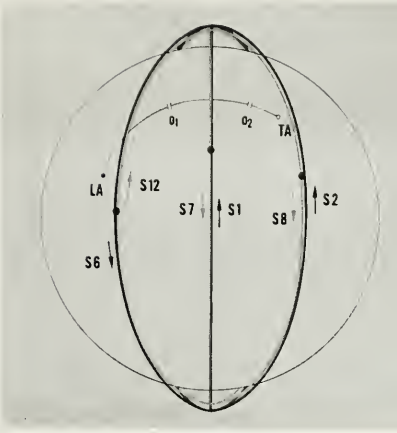


FIGURE 1

The vehicles' mean angular velocities about their respective roll and yaw axes would be zero. Thus, there could be located about each vehicle a number of directional gimbaled antennas, one of which would be capable of tracking targets in any direction therefrom, and whose bearing and slant angles could

(Continued on Next Page)

CBM'S

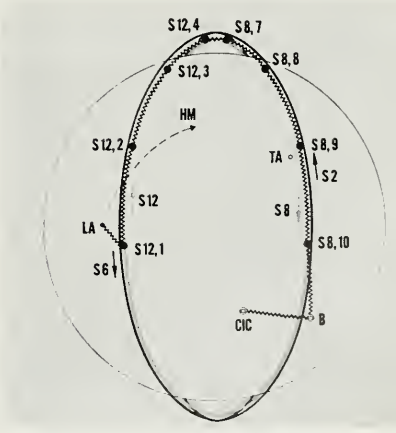


FIGURE 2

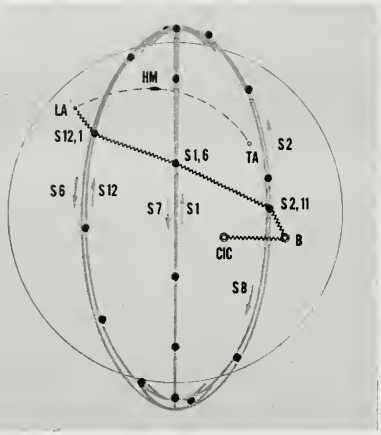


FIGURE 3

be measured relative to the vehicle's moving frame of reference. In addition, gimbaled telemetering antennas would be installed in each vehicle for the purpose of transmitting or receiving microwave communications between adjacent vehicles or between vehicles and specified stations on the earth's surface.

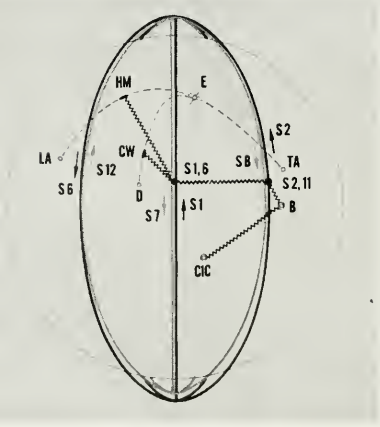


FIGURE 4

With Squadrons 1 through 6 counterorbiting with Squadrons 7 through 12, in effect no point on the earth's surface would be long hidden from the direct view of all the patrol vehicles at any time.

A hypothetical west-east ballistic trajectory is shown in the accompanying sketch on previous page, (Figure 1). Launch area LA is shown to fall within the surveillance area of Squadrons 6 and 12, and the vehicles of these squadrons would take bearing, slant angle, and slant range data on the hostile missile at sequential points along its trajectory until it reached the region of Point O_1. At some time prior to this, the vehicles of Squadrons 1 and 7 would acquire the target missile and track it until it reached the region of Point 0_2. This represents a time span between 20 and 30 minutes during which one or more counteractions will have been taken.

In the event these have proved inadequate, antimissile missiles could then be launched from the target area TA. During this time, both hostile missiles and rendezvous antimissile missiles would be tracked by vehicles in Squadrons 2 and 8.

The data obtained by the vehicles involved must be handled on a real time basis through a central coordinating agency, which could be designated Central Intelligence Command (CIC), a surface installation.

One means by which detection and tracking data could reach CIC is shown in Figure 2. Vehicles in Squadrons 12 and 6 obtain tracking data on hostile missile (HM). For purposes of this discussion, it will be assumed that vehicle S12-1 is the initial detecting and tracking vehicle. Vehicle S12-1 would relay sequential trajectory data to adjacent vehicle S12-2 which would in turn relay the message through vehicle S12-3 to vehicle S12-4. In the polar region, vehicle S12-4 would beam this information through an inter-squadron exchange to vehicle S8-7. The message would then travel along Squadron 8 through vehicles S8-8 and S8-9 where upon reaching vehicle S8-10 it might leave the squadron along a microwave ground-to-satellite relay link in direct coaxial contact with CIC. The one-way travel time for the message involved along the path just described would be of the order of 50 milliseconds.

Another channel over which the data might travel is shown in Figure 3. Here the message would be beamed between vehicles traveling abreast of one another in the same direction at essentially the same speed. The message would again be initiated with the detection of an ICBM launching at LA by vehicle S12-1. This message could then be relayed through vehicle S1-6 in Squadron 1 to vehicle S2-11 in Squadron 2, which in turn would relay the message to the surface tracking station at B from which it would travel to CIC via the previously mentioned coaxial channel. The transit time involved in this route would be of the order of 25 to 30 milliseconds.

Having received detection data followed by sufficient information to determine the ICBM's trajectory, the optimum available counterweapon would be found and action information would travel channels similar to those previously described to get it under way. CIC would monitor the counterweapon's mission to completion over the satellite network providing additional defenses as needed.

Having computed the ICBM's trajectory in inertial coordinates, CIC would direct the optimum available counterweapon to a predetermined portion of the trajectory, along which a rendezvous maneuver would be effected. While CIC would monitor the progress of the mission, actual closed loop counterweapon guidance would be effected through the nearest fleet vehicle which would track both hostile ICBM and counterweapon simultaneously. This technique would greatly reduce response time of the control loop while significantly increasing the accuracy of the counterweapons. The communication channels required for such control are shown in Figure 4.

Here, satellite vehicle S1-6 tracks hostile missile (HM) and counterweapon (CW) simultaneously in such a way as to effect a rendezvous between

(Continued on Page 26)

Doppler navigator reflector shroud assembly is checked by Assistant Foreman A. E. Froehlich after foam has been poured between Fiberglas skins to create light, strong outer wall.

THIN FOAM FOR HIGH STRENGTH

Stabilizing force provided by one-quarter inch solid froth

THIN sections of polyurethane foam provide the stabilizing force between the two Fiberglas skins of airborne Ryan Doppler automatic radar navigation sets.

Only one-quarter of an inch thick, the foam — essentially a carbon dioxide-blown plastic — is used in one of the thinnest industrial applications of its kind. The work is performed in the Ryan San Diego plant for Ryan Electronics self-contained navigation devices installed in a wide variety of Navy fixed wing aircraft and helicopters to furnish accurate navigational data without reliance on ground stations, wind estimates, or true air speed information.

A radar reflector sub-assembly consists of two septum polyester Fiberglas metal-coated skins, bonded to a prefabricated honeycomb sandwich to form a septum wall. A slot is left within the wall for installation of the wave guide which feeds energy into transmitting reflectors.

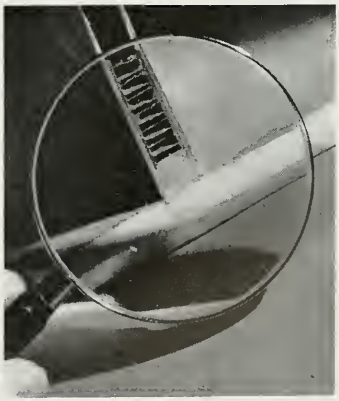
The reflector's outer shell is placed in the foaming fixture cavity. Foam is mixed and poured into the outer shell, and the inner reflector assembly is dropped into position.

The liquid foam rises in the space between the two Fiberglas skins polymerizing to a solid froth after it has expanded to completely fill the volume between the skins.

Curing of the foam is effected at 260 deg. F in the foaming fixture for 6 hours. This is followed by a thermal shock treatment, in which the foam undergoes a temperature of 185 deg. F in an oven for 30 minutes, then is frozen to minus 65 deg. F for the same period.

The hot-cold treatment is cycled six times, during which any weak areas can be detected through blisters formed in the sandwich.

The result is a structure with light weight, high strength properties essential in the fabrication of reflector assemblies for the Ryan automatic navigation sets.



Magnified view of quarter-inch foam core between paper-thin Fiberglas skins. Perpendicular to core is honeycomb separator which forms septum wall; wave guide is installed in slot left within the wall.

Aileron framework of A-1 replica is examined by Navy officers and civilians who coordinated construction. Project director was W. T. Immenschuh, right, Ryan Aerospace Chief Engineer.

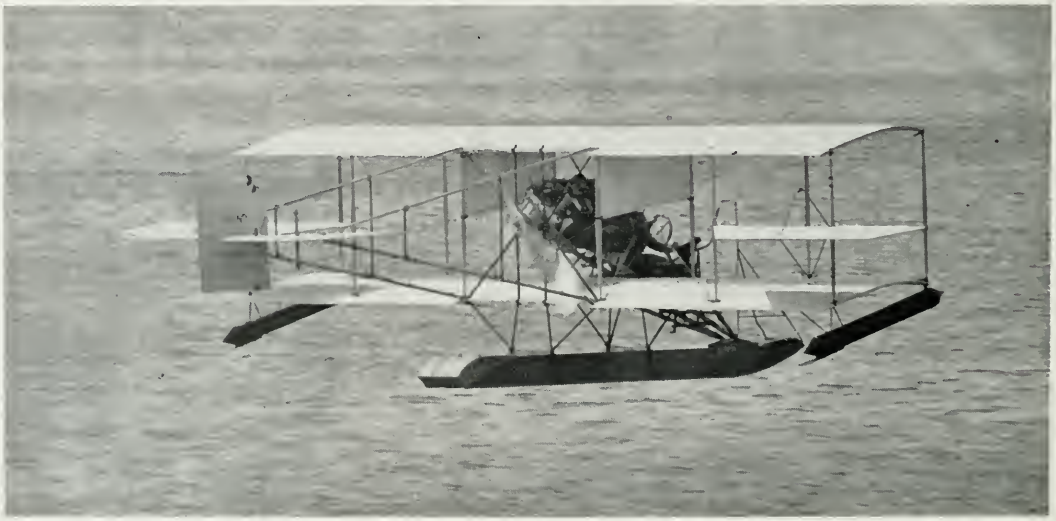
Volunteers recreate first Navy plane—Curtiss A-1 —for anniversary

MOTORISTS along the Coronado Silver Strand stared unbelievingly at the box-like flying machine humming over the southern reaches of San Diego Bay, some 100 feet above the water.

It was a "flashback" to another day more than 50 years ago, an anachronism of the skies on a July morning of 1961. Modern engineering and fabrication methods had created an amazingly faithful flying replica of the Navy's first successful aircraft, Glenn Curtiss' A-1, and this was the first test flight, only a few hundred yards from the shallow bight from which Curtiss himself took off for the first time Jan. 26, 1911, to literally launch Naval aviation.

The pilot half a century later — Don Germeraad, a Reserve Navy Commander who had taken time off from

FIFTY YEARS OF



Fifty-year "flashback" startled observers as this faithful replica of Navy's first plane made initial test flight over San Diego Bay.

Naval aviation was born in 1911 when Glenn Curtiss and Lt. T. G. Ellyson made first flights from San Diego Bay in A-1 seaplane.

NAVAL AVIATION

testing Convair 990 transports at nearly the speed of sound to re-live the thrill of an aviation pioneer as he maneuvered the replica at top velocity of 56 miles an hour.

"Glenn Curtiss would have been glad to trade his plane hands down for this," Germeraad said as he stepped out of the open-air seat on return to the North Island Naval Air Station.

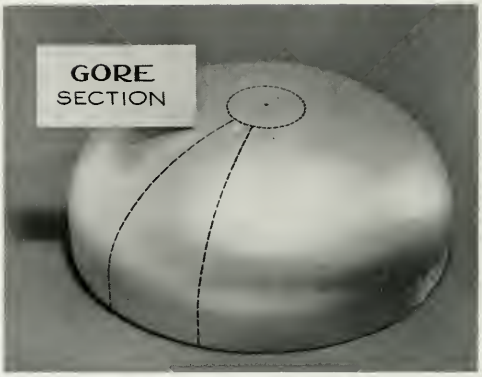
Expressing amazement at the successful performance on its first flight, Navy officers accepted the aircraft into the official Navy inventory and duly awarded it a serial number, 000001—five zeros for each of the five decades of Naval aviation, and 1 to signify this was the Navy's first plane.

On August 19-20, the A-1 replica will, weather permitting, be again taken aloft by Germeraad as the highlight of a North Island air show celebrating the Golden Anniversary of Naval Aviation.

Construction of the A-1 "carbon copy" is a story of the dedicated volunteer efforts of some 100 engineers, mechanics, and just plain hobbyists in teamwork between the Institute of Aerospace Sciences, San Diego chapter, and the Navy.

(Continued on Page 25)

Wind tunnel tests with this model preceded actual flights of Curtiss A-1 replica, which will highlight San Diego air show celebrating 50th Anniversary of Naval Aviation August 19-20.



40-ton concrete die, one of largest of its kind in the world, is used for explosive forming of giant pie-shaped gore, one section of elliptical dome for rocket fuel tanks. Its size presents exceptional forming problems.

SHAPE

Explosive charg

by James P. Orr
Assistant Manager
Manufacturing and Development

Wide variety of sizes, materials are used in dies for explosive forming. Pictured are dies of epoxy-faced concrete, ductile iron and kirksite.

FOR THE SPACE AGE

orm tough, exotic metals

EXPLOSIVE forming as a technique for shaping tough, exotic metals of the Space Age has been intensively investigated by Ryan Aerospace technicians for more than three years. The pioneering has been performed in an experimental facility at the Main plant on Lindbergh Field, San Diego, and in a production setup established on Kearny Mesa, San Diego, where three circular water-filled tanks ranging in diameter from 5 feet to 25 feet, have been used for a wide variety of parts difficult to form by conventional methods on drop hammers, stretch presses, and brakes.

Small charges of explosive are detonated in the tank, into which the metal part to be shaped is placed in a die. The explosion forces the water against the part into the shape of the die. By this means, parts are shaped in milliseconds, contrasted with much slower speeds in ordinary forming machine methods.

An impressive body of knowledge, applicable to the improvement of modern aircraft and missile fabrication, has been acquired through Ryan's numerous development and production programs. Sufficient data has been obtained from which to draw worthwhile conclusions.

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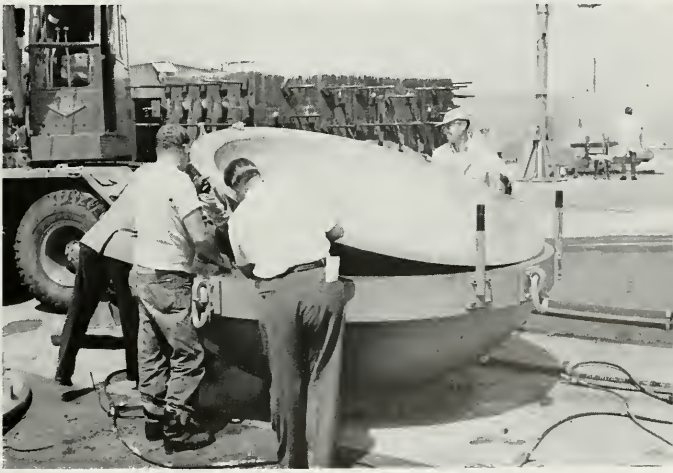
Parabolic-shaped, .120 inch thick aluminum alloy part being removed from explosive forming die at Ryan Kearny Mesa facility, is 78 inches in diameter. It will be used in improved type of military radar installation.



TOOLING

As a general rule, a tool for explosive forming is less costly than conventional dies, inasmuch as the punch is eliminated, and only a die is required.

The following materials have been used and tested, and demonstrate certain abilities and limitations:

Kirksite—Can be used to produce inexpensive short-run jobs, particularly where the metal is of relatively light gage, requiring explosive pressures in the low range.

Kirksite is not recommended for dies to be used for long range production as it tends to grow in size, and may eventually produce parts over blueprint tolerance. Kirksite is recommended only for light gage parts, of which 50 pieces or less are expected to be produced.

Hemispherical form is one of wide variety of parts that are being shaped with charges of explosive detonated in water-filled tanks at Ryan's facility on Kearny Mesa.

Ductile Iron—Possesses the best characteristics for explosive forming dies found to date. The material has not compacted (causing dies to become oversize) with the explosive pressures used thus far. It has shown good strength and ability to withstand explosive shock, and has not been excessively porous so as to create problems in securing a proper vacuum.

Concrete With Epoxy Face—As larger dies are required, the ability of the foundry to cast suitable billets from which the die is to be formed is limited. Therefore, die material which is not restricted by size limitations must be used.

Concrete dies with epoxy faces, thus far, seem best able to meet the requirements for extremely large die sizes. The technique used at Ryan is to pre-

(Continued on Page 22)

Loaded with blank part, die is lowered into 25-foot diameter explosive forming pit. Hydraulic jacks around periphery of port apply 60 tons pressure each to draw ring during explosive forming operation.

Ryonav IV Doppler navigation set underwent intensive evaluation program on company's DC-3 in flights over San Diego and vicinity.

RYANAV IV MAKES DEBUT

Ryan Electronics introduces world's first universal Doppler navigator

THE new Ryan Electronics navigation system, Ryanav IV, publicly shown for the first time at the 1961 Paris Air Show, is the world's first universal Doppler navigator—a lightweight set applicable to all types of aircraft, including fixed wing, rotary wing, V/STOL and drones.

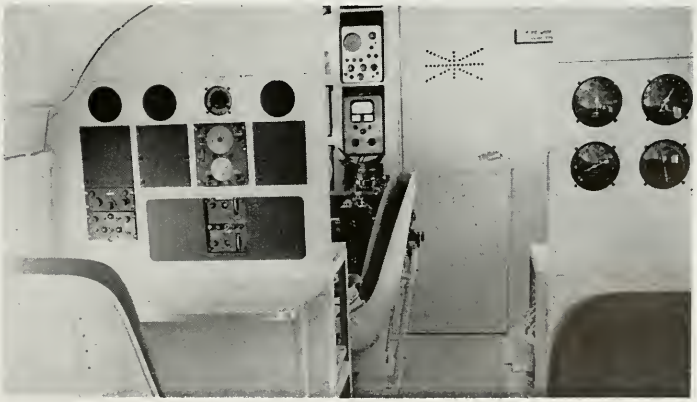
It is completely self-contained and provides accurate, continuous, all-weather, automatic navigation and hovering anywhere in the world, without radio aids, wind estimates, or true air speed data.

The system accommodates all speed ranges from minus 50 knots to plus 2,000, all altitudes from zero to 70,000 feet, drift velocities from zero to plus or minus 300 knots, ground velocities from minus 50 knots to plus

(Continued on Page 24)

Practical instruction in use of Doppler navigation device is provided in-flight by DC-3 assigned to Ryan Electronics.

Looking forward from passenger compartment of Ryan's DC-3, photo shows flight engineer's station, left, with instruments and control units. Open door at center provides partial view of the Doppler monitoring station utilized in Ryanav IV evaluation.



Special electronic scoring equipment is being installed on Q-2C Firebee targets in production line at Ryan plant in San Diego.

WILLIAM TELL 1961'S "FLYIN

AS Ryan Q-2C Firebees go into action in "Project William Tell 1961", the Air Force World-Wide Weapons Meet, they'll be equipped with "extras" further enhancing the versatility of these free-flying jet targets.

The additional equipment being installed on a modification assembly line at the Ryan San Diego plant will enable the Air Defense Command to determine with extreme accuracy the effectiveness of its missile-firing fighter-interceptors in what has been described by USAF Chief of Staff General Curtis LeMay as "the most realistic

Nose cone containing PARAMI (Parsons Airborne Ring-Around Miss Distance Indicator) antennas is installed on Q-2C Firebee.

proving ground, short of actual combat conditions, that we can provide."

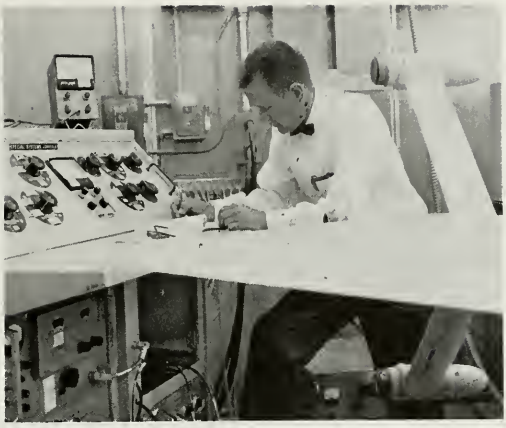
One hundred and ten Q-2C's have been assigned to "Project William Tell 1961" at Tyndall AFB, Florida, October 16-26, the third time Ryan Firebees have been chosen as the exclusive targets for this competition between the top USAF fighter-interceptor teams from throughout the world.

Streaming into the modification line, where they are prepared for the special requirements of "William Tell", are Firebees directly from the San Diego plant production facility, and others from Air Force storage.

On the "mod line" they are converted into high speed "flying scoreboards". Major installations include special electronic scoring and telemetry equipment which, in effect, permit preservation of the target while recording its hypothetical destruction. Principal systems are:

MATTS (Multiple Airborne Trajectory Tracking System), developed by Cubic Corporation. This consists of two components installed in the target's forward section—a power supply and a controller with an associated antenna system used in conjunction with a compatible ground station which feeds information to a computer system to obtain data regarding the missile and target track.

MATTS is employed for trajectory tracking, utilizing two ground stations a given distance apart to effect triangulation with the Firebee. The same stations track the missile transponder, and can determine how closely the



Wingtip infrared flares which help protect Q-2C from destruction by accurately homing missiles, are checked by engineer.

PARAMI transponder, unit of scoring system, is located in forward section.

In metal-shielded room, modified Q-2C's receive final electronic checks.

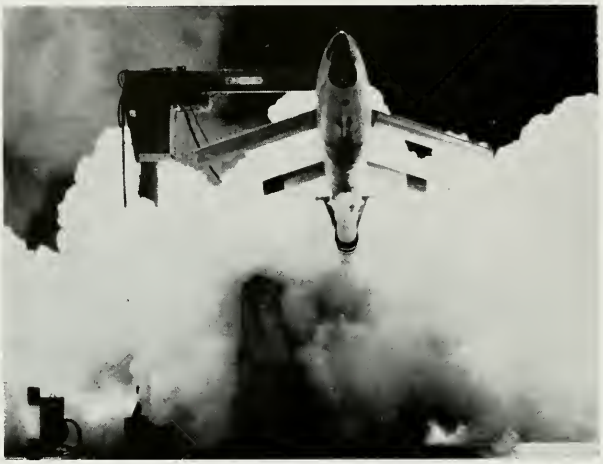
COREBOARD"

missile approaches the target, to achieve a 'kill" without actually destroying the Firebee, which is recoverable by parachute for repeated missions.

PARAMI (Parsons Airborne Ring-Around Miss Distance Indicator), provided by Ralph M. Parsons Company, also measures the miss distance. The PARAMI transponder emits a continuous signal from the target; when this signal intersects that of the missile transponder, the information is transmited to a ground station, which measures the closing distance.

To help protect the flying scoreboard from destruction by accurately homing missiles, an *infrared augmentation system,* designed and developed by Ryan for the Q-2C, is installed on the "mod line". Three infrared flares, produced by the U. S. Flare Corp., placed on each wing tip, consist of 13-inch long tubes, loaded with a metallic and

(Continued on Page 28)



Army Boosts White Sands Firebee Use

Accelerated use of Ryan Firebee jet targets by the U.S. Army in its surface-to-air missile firing program at White Sands Missile Range, N.M., has been underway since the start of the new fiscal year July 1.

Ryan Aerospace has been awarded a $555,000 contract to provide specialized personnel and services for continuation of the Firebee ground launchings which have taken place at White Sands since 1959.

The present crew under Art Akers, flight test group engineer, is being expanded to 24 men in line with the Army's desire to increase the rate of Firebee missions.

Q-2A target missiles are being modified by the Ryan crew at White Sands for ground launch capability.

In addition, the contract calls for three Model 124-E Firebees (photo below), a special Army configuration of the Q-2C, most advanced Firebee in production. Two Model 124-E prototypes have already been delivered to White Sands under a previously announced contract. The three additional "birds" in the new contract are being modified from the basic Q-2C in Ryan's San Diego plant.

Ryanites successfully demonstrated the reliability of Firebee firings first from a rail launcher and later from a zero-length launcher, the technique now being used. Now past the testing phase, the Ryan drones are being used operationally to challenge effectiveness of the Army's ground-to-air missiles in target missions over the White Sands desert range.

The first targets used were of the early XM21 series, which proved so dependable that when the originally estimated total of 66 flights for the ground launch development program were completed, Akers' crew was able to launch an additional 55 regular support missions with the assigned complement of drones.

The long-lived XM21's have been expended, and the later Q-2A series is now being operated at White Sands in target flights.

Shapes For The Space Age

(Continued from Page 18)

pare a plaster master of the die cavity. This master is then coated with approximately 1 inch of epoxy resin. A metal cylindrical section is placed over the master; a suitable amount of retaining rod is placed within the section, and finally, a high strength, lightweight concrete is put into the section to form the die.

After hardening, concrete and epoxy face are removed from the plaster and the die is completed.

FORMING AT ELEVATED TEMPERATURES

Preliminary tests with titanium, molybdenum and refractory metals demonstrated that these could not be readily explosive-formed at ambient temperatures.

A technique was conceived whereby explosive forming could be handled at elevated temperatures. One of the first considerations was the selection of a shock transmitting medium which would withstand high temperatures. It was determined that sand answered the requirements satisfactorily.

Another consideration was the method of heating the die and the blank. This problem has been solved by using Cal-rods imbedded in a ductile iron die and in a steel draw ring to elevate the temperature of the die and the blank.

One of the first parts to be formed by this technique was a titanium helmet-like shape. Parts were deep drawn from a flat disc into the helmet shape by elevating the temperature of the blank to 1200 deg. F. Thinning was held to a maximum of 0.007 inch. Material thickness in this case was 0.1075 inch.

EXPLOSIVE-FORMED PARTS

Configurations having unusual bulges and shapes are readily formed by explosive means. Because the pressure generated from an explosion travels in all directions, bulges may be formed which would be impossible or impractical to form with a punch and die.

Ryan experience also has shown that explosive forming is uniquely fit-

(Continued on Next Page)

ted for shaping extremely large parts, such as missile bulkheads, radar reflectors and solar concentrators.

Missile tanks on the drawing board today range up to 30 feet in diameter. The fabrication and sizing of these huge domes seem impractical with conventional equipment. Techniques are being developed to explosive-form these shapes economically and accurately.

Hemispheres may be produced by explosive-forming in sizes up to the limits of material sheet size available. Beyond the availability of sheet size, techniques are being developed to explosive-form cone frustums into hemispherical shapes. Tests to date have proved this technique entirely feasible. Hemispheres utilizing 5086 aluminum in the one-half hard condition have been welded and formed into shapes providing excellent strength.

Still another technique under development is the explosive-forming of gore segments for the production of hemispherical bulkheads up to 30 feet in diameter.

After the gores are welded together, the entire assembly may be explosive-formed and sized to provide a more perfect part than is otherwise obtainable. To provide hemispheres of unusual strength, material that is machine-milled or chem-milled into a waffle pattern is being explosive-formed with success. Because of the thin and thick sections present in this material, other methods of forming seem inadequate.

Explosive forming lends itself well to the manufacture of radar reflectors and solar concentrators because these assemblies require extremely close tolerances and unmarred surface finishes. Several tests have been made to demonstrate that highly polished surfaces on aluminum panels may be formed into shapes without causing surface imperfections.

ADVANTAGES OF EXPLOSIVE-FORMING

Size—Parts are not restricted in size by present equipment capacity, but by other restricting factors — sheet size, die size, or the ability to handle either the die or the material.

In this regard, a technique has been developed to construct the die right in the ground, either of concrete with an epoxy face or concrete with a steel face. In this manner, dies of 50 or 60 feet in diameter may be constructed. The die, in this case, becomes its own tank of water.

Pressure or Forming Force—Sufficient pressure and capacity for forming the strongest of our new superalloys is available through the medium of explosive forming. Pressures in excess of those obtainable by our largest, most modern conventional machines are readily generated by explosives.

From a practical standpoint, sufficient pressure is available to form even the most difficult parts.

Forming Speed—Conventional machines form metals at speeds up to 5 feet per second; explosive forming utilizes speeds up to hundreds of feet per second. Although still in the research stage, some tests have indicated that high rates of forming speed show advantages over slower forming speeds in increased elongation. In this connection, the type of explosives used should be considered, as explosives are manufactured which produce relatively low or high rates.

Cost Reduction—Explosive forming as a manufacturing technique will not replace conventional equipment. As a general rule, if the part can be formed satisfactorily by conventional means, it is more economical to do so.

There are exceptions to this: extremely large parts, parts with unusual contours, close tolerance parts, and parts requiring heavy pressures generally lend themselves to explosive forming.

Reduced Spring-Back—Parts have been consistently produced to within 0.001 or 0.002 in. of the die. This is possible because of the lack of spring-back encountered in explosive forming. Of the hundreds of dies which have been produced for this technique, not one has been machined so as to allow for spring-back. Spring-back has always been less than the tolerance allowed on the engineering drawing.

Work Hardening—Material formed by explosive means may be work hardened, and this is proportional to the severity of the form. Normal annealing methods may be employed, as with conventional forming. This may be carried on between explosive forming shots. It is generally not necessary to build stage dies in explosive forming work since the material may be moved by small explosive charges a portion of the way to the die, annealed, re-installed in the die, and finish formed.

Work hardening has been used to advantage in obtaining high tensile strength in certain alloys which are not heat treatable. Alloys, as AM355 steel and 5086 aluminum, may be uniformly work hardened through the use of explosives. The application of uniform pressure and resulting uniform elongation results in the production of hemispheres and other shapes which have demonstrated uniform mechanical properties. AM355 steel, for example, has been successfully work hardened to 230,000 psi yield by explosive means.

Astronauts Learn About 'Flex Wing'

America's astronauts have displayed personal interest in Ryan's "Flex Wing" program.

Four of the seven in the "man-in-space" project were recently briefed on the "Flex Wing" by Cecil Craigo, Ryan engineering manager of the program.

C. E. Craigo

On completion of negotiations at Ft. Eustis, Va. with the Army Transportation Research Command for a study contract, Craigo visited Langley Field, Va., where wind tunnel facilities are being utilized in the "Flex Wing" project.

There he addressed Alan B. Shepard, the first American shot into space; Leroy G. Cooper, Walter M. Schirra, and Malcolm S. Carpenter, on applications of the "Flex Wing" as an unmanned glider for recovery of space vehicles.

Among the announced study contracts on which Ryan engineers are now working in the "Flex Wing" program is one with the National Aeronautics and Space Administration — on means of recovering the extremely expensive Saturn space vehicle booster which would otherwise burn out and fall into the sea.

GROUND/WIND VELOCITY INDICATOR

2,000, ground track from zero to 360 degrees, and vertical velocities to 60,000 feet per minute.

Velocity error is less than one-half percent and navigation positional error 0.7 percent of the distance traveled. The hovering threshold is one-fourth knot. The use of pure continuous-wave (C-W) techniques permits this accuracy to be achieved without altitude or attitude "holes," from take-off to landing.

The Ryanav IV is the world's first universal Doppler navigator. Its electrical outputs are: heading velocity, drift velocity, vertical velocity, ground speed, ground track, drift angle, true heading, and east-west north-south distance traveled. Visual displays include a navigation indicator showing ground speed and ground track, or wind speed and wind heading; a hovering indicator showing heading velocity, drift velocity, and vertical velocity, and a control indicator with five switch positions: Off, Silence, Land, Sea, and Test.

The receiver-transmitter in the Ryanav IV is designed as a space-duplexed, fixed-antenna system which has no moving parts and requires no adjustments, assuring virtually 100 percent reliability of the microwave system. This antenna, combined with an all-attitude ground speed computer, provides accurate outputs over a wide range of aircraft pitch, roll, and drift angles. Attitude capability is not limited by radome cutout area or gimbals usually found in systems which employ stabilized antennas. Supersonic speeds are accommodated simply by shifting the receiver band. No change in antenna angles or other system parameters is necessary.

Outputs are provided for tie-in with plotting boards and other position indicating equipment, course and distance computing and indicating equipment, inertial navigation equipment, bomb director sets, antisubmarine warfare sets, and terrain clearance radar. The set can be used with integrated flight systems, autopilots, automatic stabilization equipment, and flight director systems — for aircraft which fly at low as well as high altitudes.

The various configurations of the Ryanav IV family of Doppler ground velocity indicators may omit, modify, or add certain units to meet specific needs. Antennas can be provided to meet specialized aircraft structural or operational requirements.

The set also incorporates provisions for self-contained functional and calibration tests. A system test set, module test set, and test bench harness simplify checkout.

The Ryanav IV employs continuous-wave electromagnetic energy at a frequency of 13,300 megacycles as authorized by the Federal Communications Commission. The set's antenna directs this energy toward the earth's surface in three narrow beams. The frequency of the energy backscattered from the ground is "Doppler shifted" by an amount which is proportional to the aircraft's velocity along the individual beam. The three Doppler frequencies are measured and used to compute the aircraft's velocity components. This is accomplished in the converter/computer unit which comprises a low voltage power supply module, a frequency tracker module,

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RYANAV IV CONTROL INDICATOR

HOVERING INDICATOR

a frequency converter velocity computer module, and a computer module.

Ryan Electronics pioneered the use of C-W Doppler radar with the U. S. Government, proving this technique to be the most suitable to accommodate the positive, negative, and zero speed domains, the near-zero altitude requirements of helicopters and V/STOL vehicles, and high altitude requirements. The Ryanav IV is the latest addition to Ryan line of automatic navigators, which includes such volume production models as the AN/APN-97A Ground Velocity Indicator for helicopters, the AN/APN-122(V) for fixed-wing aircraft, the AN/APN-129 (V) for Army fixed-wing aircraft, and the AN/APN-130 for advanced, high performance helicopters. These sets involve thousands of production units on order for more than 25 different types of military aircraft.

500th KC-135 fuselage section built for The Boeing Company is pictured as it rolled off the assembly line recently at Ryan's San Diego plant. Officially receiving the giant unit are Boeing tooling representatives, Harry Varon, at left, and Swight Hansen, next to him; and D. M. Christie, second from right, Boeing Buying-Supervisor. Ryan officials are H. E. Dukes, center, Airframe Superintendent; and Lew Pratt, right, Manager, Major Assembly Sub Contracts.

New Ryan Order For Fuselage Sections Exceeds $9 Million

A new follow-on order exceeding $9 million for production of giant aft fuselage sections for Boeing KC-135 jet tankers and C-135 transport airplanes has been received by Ryan Aeronautical Company, T. Claude Ryan, President, announced recently. The new contract, Ryan said, assures production well into 1963.

The new order is the eighth contract awarded Ryan by The Boeing Company since work on the KC-135 project began in 1955. The 500th fuselage section in this series of orders was completed and rolled off the assembly line at Ryan's San Diego plant on Thursday, July 20.

The 40-foot long, 3-ton units are the largest ever subcontracted on a volume production basis in the aircraft industry. They are shipped to Renton, Washington, in specially designed holding fixtures on railroad flat cars.

The high-flying, high-speed KC-135 is the Air Force's chief "aerial gasoline station," utilized for mid-air refueling of jet bombers and fighters to extend their non-stop range for combat and patrol missions.

Fifty Years of Naval Aviation

(Continued from Page 15)

Director of the project was William T. Immenschuh, Chief Engineer of Ryan Aerospace, and construction supervisor was William S. Cockrell, senior group engineer at Ryan. Vincent Carlson of General Dynamics-Convair, San Diego, was project engineer, and A. V. "Fred" Verville, technical advisor to the Director of Engineering, Bureau of Naval Weapons, drew on his wealth of background as an aviation pioneer and associate of Curtiss to provide invaluable over-all guidance, and liaison between the Institute of the Aerospace Sciences and the Bureau of Naval Weapons.

"The original material on the Curtiss A-1 still available was not very extensive," Immenschuh said. "There was a photostat of a three-view drawing, with 9 dimensions, made by Curtiss and dated Aug. 26, 1911. And we relied on old photos, articles in old publications, and letters and information recalled by old-timers who had seen the A-1."

From such information, stacks of engineering blueprints were made. Parts were fabricated in dozens of backyard workshops and home garages. Ryan, Convair and Navy civil service employees gave thousands of hours of their time in this labor of love. Some 20 industrial firms throughout the country donated materials and labor, and the Navy supplied an authentic original OX-5 engine.

Sub assemblies were made in the San Diego Marine Corps Recruit Depot hobby shop, and the expert final assembly work was performed by the Navy Overhaul and Repair Department at North Island.

Structurally, the A-1 replica is authentic except for minor deviations in the interest of safety, as dictated by 50 years of accumulated experience and knowledge. Thus, the tailbooms are aluminum, instead of bamboo; resin-type adhesive was used for laminating, instead of the furniture glue of

(Continued on Next Page)

Army Colonel Views Q-2C Line

Q-2C Firebee production line was visited recently by Col. Fred. F. Quist, Deputy Chief, Communications and Electronics Division, Office of the Chief of Research and Development, U.S. Army. He is shown with Jack Lucast, at left, Manager, Target and Drones; and Herb Covell, right, Military Relations Engineer.

Fifty Years of Naval Aviation

(Continued from Page 25)

1911; spars are of ash, sturdier than the spruce of the original; the keel is of mahogany plywood, instead of spruce; and aircraft cables are utilized with modern turnbuckles (Curtiss used turnbuckles from motorcycle spokes).

There also are a few alterations in the controls. Curtiss had a shoulder yoke for manipulating the ailerons — he swayed back and forth to bank the aircraft. Rudder pedals in the 1961 version replace the wheel control for the rudder.

But the design came so close to the original that the "new" A-1 is "basically as aerodynamically and hydrodynamically unstable, with a tendency to porpoise on take-off, little directional control provided by the rudder in flight, and adverse yaw with roll," Germeraad points out.

"You've got to hand it to those old-timer fliers, handling these planes," he remarked. "They had to fly their aircraft every second."

After its flights, the replica will be restored, in minute detail, to the features of the original.

The Curtiss A-1 may not have met today's F.A.A. standards, but it was one of the world's most significant planes. Curtiss' flight from San Diego Bay, Jan. 26, 1911, and a subsequent take-off the next day by his student, Lt. Theodore G. Ellyson, then Navy's Number 1 aviator, forever freed aviation from the restrictions of land-locked airfields.

Not satisfied with the remarkable creation of a flying replica of a remarkable plane, the I.A.S. and the Navy are teaming up on construction of a second full-scale model, which will be enshrined in the Smithsonian Institution, Washington, D. C.

Meanwhile, San Diego hopes to obtain permanent possession of the first A-1 duplicate to symbolize its claims as the birthplace of Naval aviation.

"Way Out" Mirror

(Continued from Page 9)

does not depend upon pressure or temperature-sensitive chemical or fluid flow processes, there is maximum assurance that ground demonstrations and pre-launch checkout tests actually prove the capability and reliability of the system for space environment.

All-metal construction provides resistance to sublimation, radiation bombardment of micro-meteorites and other effects of the space environment which might seriously reduce the useful life of structures made from organic materials.

Regardless of scale or environment, use of metal enables production of a stable structure with predictable contour for the reflecting surface material, and with minimum weight.

A major problem is the achievement of high reflectivity at short wave lengths. Polishing development and reflectivity studies are being continued to attain the required surface perfection for optimum performance of an evaporated film of aluminum or silver deposited directly on the polished mirror skin.

Meanwhile, Ryan engineers and technicians continue to improve critical fabrication methods in this field of space technology.

Tracking Enemy ICBM's

(Continued from Page 12)

them at (E). Simultaneously, trajectory data on both would travel between satellites S1-6 and S2-11 to surface tracking station (B) and thence to CIC which would monitor the countermission for the purpose of directing secondary defenses if needed. While closed loop control is effected through satellite S1-6, rendezvous point (E) and coarse counterweapon trajectory would be determined by surface computers physically located at CIC. The counterweapon launching facility (D) should lie approximately midway along the surface projection of the hostile missile trajectory, i.e., approximately midway between LA and (TA) in Figure 11. By launching the counter-

(Continued on Next Page)

weapon from an area so located, advantage could be taken of the rendezvous technique which brings the counterweapon into effective range of the hostile missile for a much greater time interval than is possible for antimissile missile defense techniques. An additional and perhaps equally important advantage is gained in the fact that the hostile missile might be following a trajectory purposely or otherwise which would cause it to destroy an undefended target. The broad control which could be exercised over the counterweapon trajectory would make it possible to effectively defend target areas not having antimissile missile installations.

In orbit each stabilized vehicle constitutes a moving orbital platform from which suitable electronic equipment might operate so as to detect ICBMs during launch or at any subsequent phase in their ballistic trajectories.

The detection cross-section of an ICBM will vary from the time it is launched until the time it re-enters earth's atmosphere. At launch, chemical energy will be released at a high rate during the first few minutes of flight. While still on the ground, the ionized rocket exhausts will be characterized by high velocities and high temperatures from which a unique Doppler radar return might be sensed. The high temperature area could be detected at long range by infrared techniques. Under ideal conditions, optical sensors might detect the brilliant chemical reaction. Smoke and steam emanating from the launch area might also be detectable under clear weather conditions. It will be assumed that inertial techniques will be used to guide the hostile ICBM into its trajectory, although advantage might be taken of any radio or radar emanations employed.

The following is a list of electronic equipments thought to be needed aboard a satellite patrol vehicle:

a. One PPI search radar, pulse-echo, range 2560 km., 95° fan shaped antenna pattern, for upper hemisphere use, to detect targets moving at velocities above Mach III —small radar cross-section targets.
b. One PPI search radar, pulse-echo, range 1600 km., 35° fan shaped antenna pattern, for lower hemisphere use, to detect medium radar cross-section targets moving below Mach III.
c. Eight automatic tracking radars, pulse-echo, range 2560 km., pencil beam antenna patterns, for upper hemisphere use, to track targets above Mach III.
d. Four automatic tracking radars, pulse-echo, range 1600 km., pencil beam antenna patterns, for lower hemisphere use to track targets below Mach III.
e. One CW Doppler radar horizontal velocity sensor for use at altitudes ranging between 120 and 400 km., dynamic range 7.5 to 8.0 km/sec (roll axis orientation).
f. One radar altimeter, for altitudes between 120 and 400 km.
g. Three sensors for establishing yaw axis vertical.
h. Star-tracking capability for orbital plane correction.
i. Star-tracking capability for indexing beneath Polaris.
j. Four tracking antennas for line-of-sight communication between vehicles and squadrons.
k. One tracking antenna for space-to-surface line-of-sight communications.
l. Infrared sensors as required.
m. Optical sensors as required.
n. CW Doppler radar sensors as required.

The vehicle proper would require the following support equipment:

1. Four multimessage broadband microwave communication transceivers (presumably with carriers of different frequencies and capable of tracking carrier Doppler shifts up to 500 kc).
2. Multimessage data storage equipment.
3. Multitracking command guidance equipment.
4. Adequate secondary power supply to excite above listed equipments, and, last but not least,
5. In-orbit propulsion capability (primary power) to maintain its specified post.

Even though optimized equipment were employed in every case, it seems evident that the patrol vehicle having all of the equipment described would still exceed the injection mass capabilities of any available or presently projected propulsion system. Thus one can conclude that, in addition to microminiaturizing the instrumentation and optimizing its efficiency, there may be an additional requirement for optimizing propulsion capability.

CONCLUSIONS

1. **An optimum reliable future defense against intercontinental ballistic missiles may depend upon the development of entirely new propulsion techniques.**
2. **Such future defenses would not be limited to strategic areas protected by antimissile missile installations.**
3. **Both microminiaturizaton techniques and advanced launching (propulsion) capabilities would be needed.**
4. **The required functions outlined do not appear to exceed the present state of the electronic art.**
5. **Some continued in-orbit propulsion capability would be required.**
6. **New rendezvous antimissile missiles would be needed.**
7. **The counter weapon missions would require precise coordination to a degree which would be impossible without the simultaneous line-of-sight tracking-guidance function which would be inherent in the subject fleet.**
8. **A worldwide jamproof communication network virtually free of local atmospheric disturbances would appear possible.**
9. **A worldwide air-sea-space navigation and rescue aid capability would be inherent in an orbiting satellite fleet.**

Navy Launches Q-2C Project

Another milestone in the utilization of Ryan Q-2C Firebee jet target drones by the nation's air defense forces was achieved recently with the first operational flight by a Fleet unit of the Navy.

Launched from a P2V Neptune based at the North Island Naval Air Station, San Diego, the Q-2C was operated by personnel of Squadron VU-3 and remotely controlled from the new ground station at San Nicolas Island, off the Southern California coast.

All previous flights of Navy Q-2C's, dating back to early this year, had been of an evaluation nature in the intensive testing program under way at the Naval Missile Center, Pt. Mugu, Calif. Photo shows Q-2C secured to the wing of a Neptune launch plane at Pt. Mugu, where Ryan technicians assist Navy crews in developing maintenance and operating procedures.

The Q-2C's, most advanced of the Firebees now in production, will eventually replace the KDA series in Fleet use at Squadron VU-3, North Island; Squadron VU-8, Roosevelt Roads Naval Air Station, Puerto Rico; and the Naval Missile Center, Pt. Mugu.

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William Tell 1961's "Flying Scoreboard"

(Continued from Page 21)

powder composition. Extending outwardly from the wing, the flares provide sufficient energy to attract heat-seeking missiles, which are thus able to score "kills" without total damage to the target.

Telemetering indication is installed to depict to the ground operator when the flare, commanded remotely, has ignited, and the quantity of flares remaining unused.

For the first time in a world-wide weapons meet, Ryan Firebees will be equipped with an active radar augmentation system, in contrast with passive systems such as Luneberg lenses and corner reflectors which gave fixed returns. The augmentation system designed by Ryan, creates a radar return from the target which can be adjusted to depict almost any present day threat aircraft on the interceptor's radar screen. The Q-2C thus can represent varying sizes of targets by adjusting prior to launching the traveling wave tube amplifier. The basic amplifier is a device to answer the interceptor's radar system with proper radar return for a particular mission. Radar augmentation can be provided in the nose or tail aspect, or either beam. Antennas are affixed to both tips of the horizontal stabilizer and can be remotely controlled for either left or right augmentation. Telemetry indication is provided to inform the ground operator the position or side in which the target is augmented. The traveling wave tube amplifier itself is installed in the Q-2C's equipment compartment.

For "William Tell", the targets are being given a radar augmentation configuration compatible with the GAR missiles and MB-1T rockets.

Also being installed on the modification line is an *automatic fuel expulsion system,* another feature aimed at increasing the target's longevity. At the end of a target mission when the main parachute deploys, an electrically controlled valve dumps the remaining fuel. The valve closes on water impact (at "William Tell", some targets may be retrieved from the Gulf of Mexico), to keep the tank dry.

Such jettisoning of fuel reduces weight of the target on impact, minimizing damage, improving flotation characteristics, and simplifying retrieval by recovery helicopter.

Buoyancy is further improved by installation of *molded plastic flotation blocks* in the radome nose section, around the engine, and in the wings.

Location of the floating target, as well as visual acquisition during flight, is aided by a *flashing light* of 1 million lumens peak intensity, installed just aft of the wing, in the fairing over the equipment compartment.

When the target is launched, the strobe light begins flashing at approximately 50 cycles per minute, for a duration of 3 hours on a single battery charge.

Ryan is also manufacturing kits for checkout tests at Tyndall AFB to insure functional reliability before launching, and is incorporating modifications in its aerospace ground equipment (AGE) to make it compatible with the special features installed on the "mod line".

On the "William Tell" modification line, fuselages are already mounted on shipping skids. The Air Force has requested that casters be placed under the skids to enable ground support crews at Tyndall to move the "birds" around the using area. The casters are

(Continued on Next Page)

now permitting Ryan production personnel to use the shipping skids as mobile fixtures within the assembly area, boosting efficiency and economy.

In a 20 by 28 foot room, 10 feet high, each fully assembled and modified Q-2C undergoes thorough final testing of its newly installed electronic equipment. The room is metal-shielded to confine radio frequency energy within its limits. A Ryan-designed "special systems" console just outside the room transmits signals through cables connected to the "bird", which picks up the transmission and indicates on the console the effectiveness of the equipment.

Another console checks the functioning of the Q-2C itself in a separate series of tests.

Then the "flying scoreboard" is ready for delivery to Tyndall AFB to test the sharpshooting skill of America's defenders against air attack.

I Fly the Flex Wing

(Continued from Page 2)

The first lift-off would answer many more questions. As I continued the taxi tests, these questions raced through my mind. Would the "Flex Wing" pitch up, roll over, "snake" back and forth, or just fly smoothly straight ahead?

Sitting so vulnerably out in the open, I thought:

Nothing like this has ever been herded through the air by man before. The closest to this was the hang glider experiments by Otto Lilienthal in Germany and Octave Chanute in this country, and they weren't very successful.

Speeds are building up in taxi tests. That first lift-off could come at any time . . . ease back on the control column . . . it's getting light . . . we're airborne!

It responds nicely to pitch control, a little slow to respond but we expected that because this is characteristic of the delta wing at high angles of attack.

My sensations are different from those experienced in any other flying machine. They can best be explained by imagining yourself sitting in a rocking chair controlled by a giant hand which occasionally rocks you sideways as well as back and forth.

The "Flex Wing" test bed is primarily a two-control vehicle, in that it has only pitch and roll control. Although lacking a rudder for conventional directional control, the plane has high directional stability. It has no tendency to sideslip; thus, when I bank, this stabilizing force keeps the nose coming around in a turn. For rising and descending, the wing is pitched relative to the platform by use of the conventional control column and wheel similar to that on most light planes.

There is no similarity with vertical velocity as is associated with the attitude change in conventional aircraft. You feel an up and down motion integrated with forward velocity, similar to that in a helicopter, inasmuch as the test bed remains in a relatively level attitude.

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ON THE COVER

Flying the "Flex Wing" has given Ryan Pilot Lou Everett thrills na conventional aircraft can duplicate. He tells about it an Page 1.

As for the rocking sensation, I quickly realized — and this was confirmed by motion pictures of the early flights — that this motion is confined to the platform, confirming the fact that the machine as a whole has strong stability. The wing itself has a rock-steady attribute built into its high camber, delta planform.

As a result of our early flight tests, we have progressed through what can be considered a natural course of design changes and development. Most of the changes made were directly associated with proper location of the wing control pivot point as related to the wing itself.

It must be remembered that this test bed is not to be considered even an experimental airplane. It is a research vehicle used to prove basic principles which can be applied to a wide variety of missions of manned and unmanned vehicles that may be powered or unpowered. The applications of the "Flex Wing" range from small, powered reconnaissance drones maneuvered by remote control to huge, unpowered wings capable of recovering payloads and rocket boosters of 50 tons or more.

As our flight tests of the research vehicle for the U.S. Army Transportation Research Command continue, we will be answering the big question —

Can a flexible wing flying machine utilizing control by shifting the center of gravity be adequately controlled for all potential applications?

All indications to date point to an affirmative answer.

Inherent stability, extremely low storage volume, inexpensive light weight construction which allows more effective wing area per unit-weight than a conventional wing, greater lift for a given wing weight — these are qualities of the "Flex Wing" we are proving in the current test program.

And in many ways I have the same pioneering feeling that America's first astronaut, Comdr. Alan Shepard, must have had on his initial flight in another unconventional vehicle, the Mercury capsule.

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Form 3547 requested

RYAN RESEARCH VEHICLE SPEARHEADS FLEX WING APPLICATIONS

With the world's first manned Flex Wing vehicle, Ryan engineers are uncovering valuable new flight data which will adapt this concept to a broad variety of important military and space applications.

Recovery of huge boosters, nose cones and capsules... re-entry of space vehicles at reduced velocities ... helicopter tow of logistics payloads... controlled delivery of air-dropped cargoes to "pin-point" landings... small reconnaissance drones to meet combat needs. These are a few of the multiple applications for which the Flex Wing can be used.

Based on a National Aeronautics and Space Administration concept, the Flex Wing provides greater lift per weight than fixed wings, is superior in inherent stability and can be precision-controlled in both powered and unpowered versions. It can be packaged into an extremely small volume and then deployed faster than any other deceleration or lifting devices.

Ryan Flex Wing enables helicopters to tow several times the cargo or fuel they can carry

Ryan has received several contracts from NASA and the military services to explore and develop the more promising Flex Wing applications. Pioneering an entirely new concept, such as Flex Wing, is typical of Ryan's Space Age capabilities.

Ryan Aerospace—Ryan Aeronautical Company, San Diego, California.

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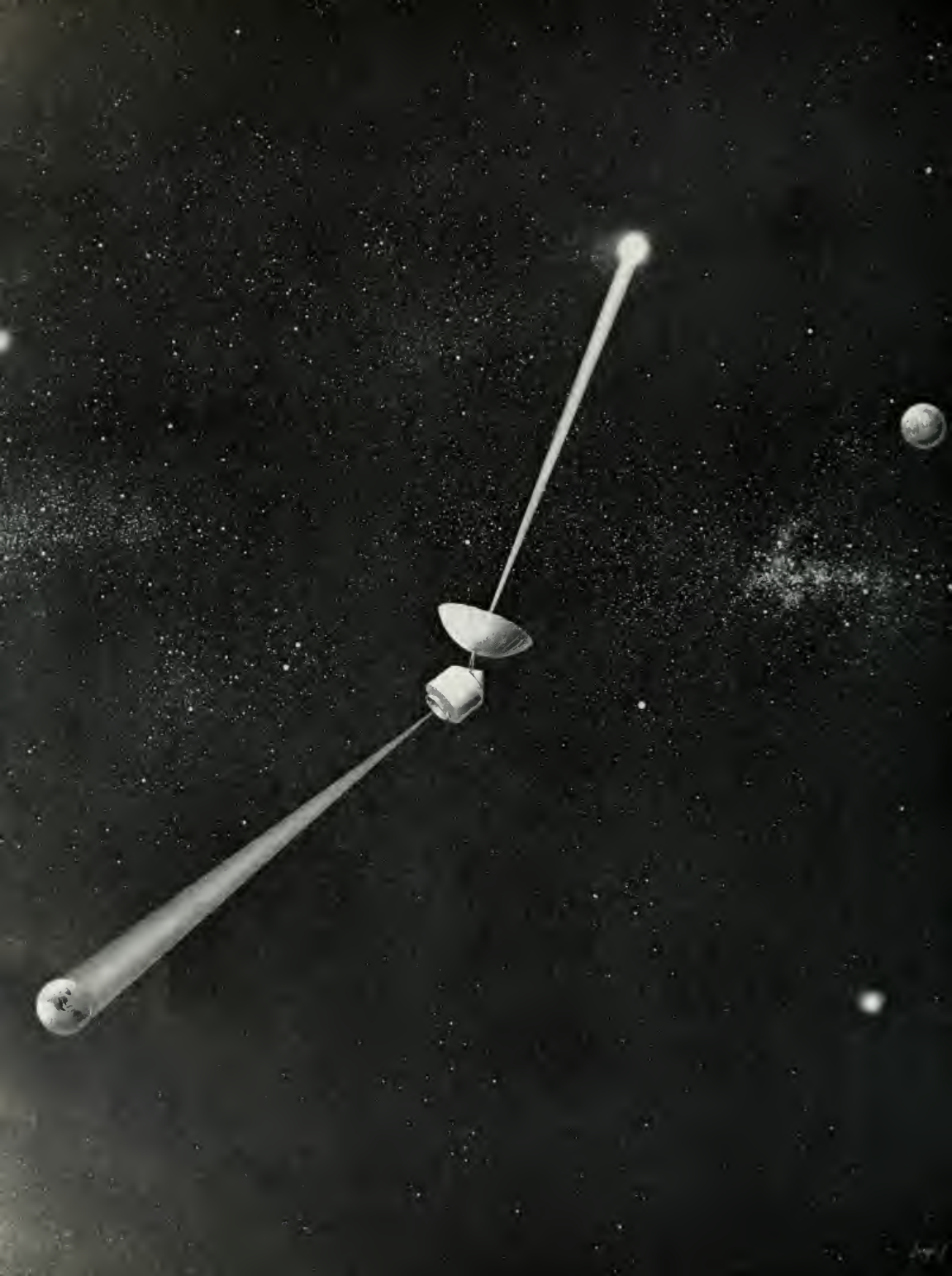
RYAN AEROSPACE

RYAN REPORTER

TILT-WING VTOL

VOL. 22, NO. 3



INTERPLANETARY NAVIGATION

Passive Doppler techniques may utilize celestial radio sources

by Maurice G. Chatelain, Advanced Design, Ryan Electronics

FROM the launching of the first artificial satellite of the earth four years ago, it has been evident that this new type of celestial body would have many practical applications, particularly in the realization of accurate navigation around the world. Now it appears that it can also be very useful for interplanetary navigation.

For several thousand years, since the early days of human travel, navigation has been based on the observation of the sun and stars. The accuracy of navigation was a function of the accuracy of observation, which was relatively low since optical techniques always contained an element of human error.

When the first artificial satellite was launched, most tracking stations around the world tried to determine its orbital parameters from the radio signals received, and it was then discovered that the most accurate technique to obtain these data was to utilize the apparent frequency shift of the transmitted signal, which is caused by the Doppler effect.

This phenomenon, discovered more than one hundred years ago by the Austrian physicist Doppler and utilized for the first time by the French physicist Fizeau, to calculate the relative velocity of stars, now constitutes the basic principle of airborne and space navigation techniques.

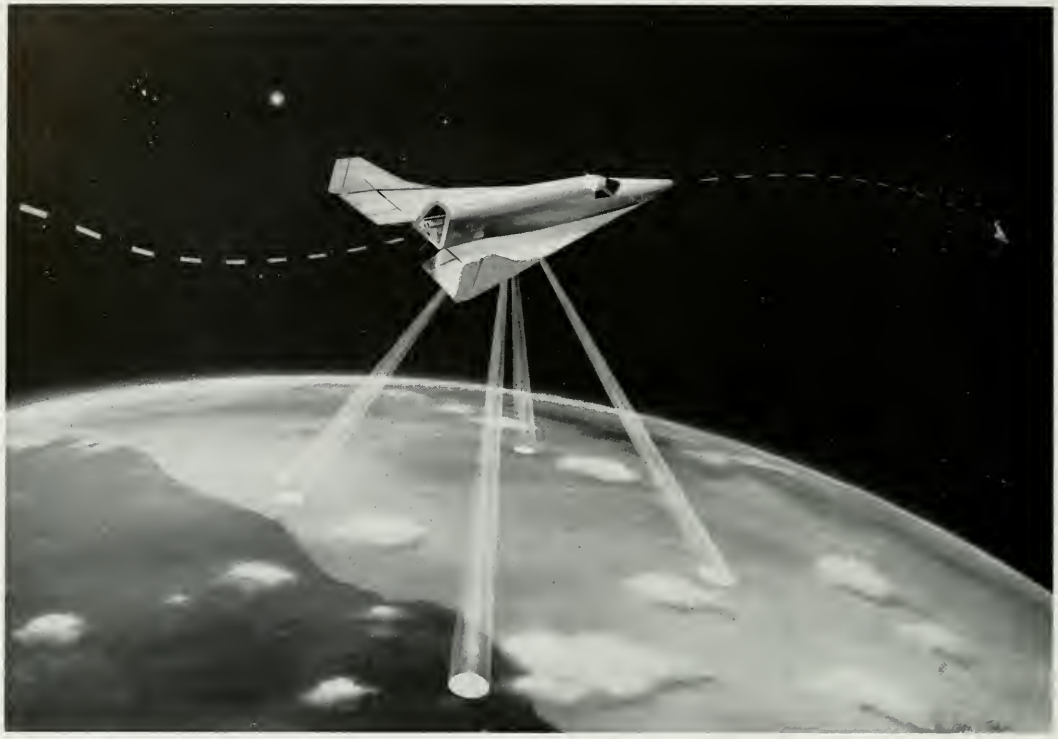
In the Doppler effect, the motion of a radio source toward a radio receiver, or vice versa, causes a certain number of wavelengths to be compressed into a shorter length, resulting in shorter apparent wavelength and higher apparent frequency. Conversely, when the radio source is receding from the radio receiver, the motion results in longer apparent wavelength and lower apparent frequency. When the velocity vector of the moving source is exactly orthogonal to the direction of the receiver, the apparent frequency and wavelength of the received signal are ident-

(Continued on Next Page)

Spiral antenna satellite technique for world-wide navigation is depicted in this artist's conception of one in global orbit.

←

Ryan Electronics engineers are studying application of neutral hydrogen radiation to interplanetary Doppler navigation.



Doppler radar would be utilized for earth-orbiting space vehicle as it prepares for a landing in predetermined area.

ical to those of the transmitted signal, which indicates that there is no Doppler frequency shift, thus no radial component of velocity.

The Doppler frequency shift is directly proportional to the relative velocity, and a curve of Doppler shift vs. time indicates with a high degree of precision the decreasing relative velocity, the time of closest position, and the increasing relative velocity of an orbiting satellite with respect to the earth.

The six orbital parameters of a satellite, namely the period, eccentricity, inclination, argument of perigee, latitude of perigee, and longitude of ascending node, can be obtained from the Doppler frequency curve of one single pass of the satellite, assuming that the accurate geographic position of the observer is known. Satellite orbital data obtained with Doppler techniques have been compared with equivalent data obtained with optical or radar techniques, and the accuracy of the Doppler technique is now established.

Conversely, once the six orbital parameters of the satellite are known, the geographic position of an observer on the surface of the earth can be obtained from the Doppler frequency shift of the transmitted signal. Moreover, since surface navigation requires the determination of only two parameters, namely the longitude and latitude, instead of the six orbital parameters required for a satellite, it may reasonably be expected that higher accuracy will be obtained. Furthermore, this technique can also be applied to airborne or spaceborne navigation, if the altitude is known.

This concept constitutes the basis of the Transit Navigation Satellite Program, presently under development by the U. S. Navy, for accurate navigation of surface ships and submarines around the globe. Four satellites, successfully placed in orbit, have established the feasibility of the concept and the possibility of obtaining a worldwide navigation network with a minimum of four satellites in circular 400-mile orbits and a few tracking stations.

However, this technique, though representing a considerable progress when compared to previous navigation

methods, presents two serious disadvantages. First, it requires the preliminary installation of ground tracking stations, and second, it requires a certain delay for transmission of the Doppler data to the central computing station, calculation of the orbital data, transmission of these data to the satellite for storage, and retransmission with the corresponding time to the observer on the surface of the earth. This delay might very well be too long for airborne and space applications, and it is highly desirable that an independent planetary navigation device be developed.

One of the methods of interplanetary navigation generally considered consists of orbiting around the planet of departure, traveling between the two planets, then orbiting around the planet of arrival until the time comes to perform the rendezvous or landing maneuver.

Interplanetary navigation is thus divided into three phases, the first and third being concerned with planetary navigation, where active Doppler techniques may be used, and the second being concerned with midcourse guidance. Passive Doppler techniques may be used for midcourse.

The problems of interplanetary midcourse navigation are entirely different from those of planetary navigation where active Doppler radar is generally considered.

In interplanetary midcourse navigation, distances to the planets of departure and arrival, as well as to other celestial bodies, are very large. Since transmitting power and antenna size are limited by weight considerations, active Doppler radar cannot be considered.

Until man discovers a revolutionary technique to obtain a reaction against the space medium itself, by electric, magnetic, or gravitic means, it appears that only two methods of midcourse navigation are available, the optical and the radiometric techniques.

The optical technique has been described by several authors and is now well known. The radiometric, or passive Doppler technique, will be described.

Advanced interplanetary navigation systems may be based on radio astronomy utilizing the 21-centimeter radiation or absorption line of neutral hydrogen.

The frequency spectrum of radio frequency radiations received from a typical region of the galaxy is without discontinuities or irregularities for the most part. However, it was predicted in 1944 by the Dutch astronomer Van De Hulst that the galactic radiation at 1420 mc might be different from the adjacent frequencies. Effectively, it was discovered in 1951 by Ewen and Purcell at Harvard University, that in a narrow frequency band, centered at 1,420,405,760 cps, the radiation intensity is approximately double that of adjacent portions of the spectrum. This is the radiation from the ground state of atomic hydrogen which constitutes an important part of the spiral arms of our galaxy and is undetectable by optical methods.

In 1955, Lilley and McClain, at NRL, obtained the relative velocity of a distant radio source receding from the earth at the fantastic velocity of 16,830 kilometers per second, from the apparent Doppler shift in the absorption line of neutral hydrogen, from 1420 to 1340 mc, thus realizing the first passive Doppler velocity sensor.

From that time on, a considerable amount of research has been accomplished by space navigation engineers as well as by radio astronomers. Ryan Electronics, a leader in active Doppler navigation, has also been engaged in studies concerning neutral hydrogen radiation and its possible applications to interplanetary passive Doppler navigation.

Sufficient data now has been gathered on celestial

(Continued on Page 28)

Soft landing of space vehicle on a foreign planet would be made possible by use of an active Doppler radar altimeter.

For nearly four decades, T. Claude Ryan, founder, Chairman of the Board and Chief Executive Officer of the Ryan Aeronautical Company, has helped write aviation history and pioneered many new concepts. He entered the fledgling industry in 1922, only 11 years after the first successful Navy plane, the Curtiss A-1, made its initial flight from San Diego Bay.

As San Diego celebrated the 50th anniversary of Naval aviation, Ryan was asked by a board of editors and reporters of The San Diego Union to look into the next half century of man's conquest of space, and to comment on current developments. Following is a condensed transcript of the interview:

INTERVIEW: SPACE AGE

Q. Do you have any forecasts or dreams of what we may see in the next 50 years of aviation? We've already cut the flight time to New York down to something like 3 to 4 hours.

A. We'll have some advancements in supersonic flight which might improve on these long flights within possibly 10 years.

Q. What will this do to the present jets?

A. I don't think it will eliminate the high subsonic jets, except on the long transcontinental and transoceanic flights. The world just isn't big enough to justify supersonic jet flights except on the long runs.

I also feel that the other end of the scale must be developed—that is, the vertical take-off transport planes that can fly at very acceptable speeds. We've been very interested in that area.

Q. What would you consider acceptable speeds?

A. These transports could go up to the high subsonic speeds and still fly and take off vertically. The first developments will probably be in the range of the present transports for short hauls—of around 300 to 400 miles an hour, but land any place a helicopter can land.

That will improve the service tremendously. As the high speed, long-distance planes have to utilize airports that are farther and farther from the center of cities, these vertical take-off planes that will land right in the center of the cities, will tend to complete the pattern.

Q. That would mean quite a radical change in the whole concept of airports and ground transportation.

A. I think the large cities would have large airports far out, and the service for anything less than 500 to 600 miles would be by these vertical take-off transports.

Q. Do you visualize perhaps doubling the number of passengers flying in the next 10 years?

A. I think that would be a conservative guess.

Q. Ryan for 30 or 40 years has almost always had an airplane with its name in the air.

A. Well, we have several right now. But one of them doesn't have a pilot in it. It's our Firebee drone, a very much more sophisticated vehicle than most of the manned airplanes. We also have the VZ-3RY Vertiplane, again being tested by NASA, and the Flex Wing, which is being tested for the Army Transportation Research Command.

In addition to such Ryan vehicles actually flying, we are in a joint venture group, composed of Chance Vought,

Hiller and Ryan, which recently won a multi-service VTOL design competition. Ryan will help develop and build five experimental tilt-wing VTOL military transports in a program which may exceed $70 million. Each of the three services—the Air Force, Navy and Army—is sharing the costs.

Q. Could this plane be sort of a prototype for passenger vertical take-off transports?

A. No, not the same plane. But the basic principles would be applicable.

Q. The same way the Boeing jet tanker developed into the 707 transport?

A. Yes, very definitely. This airplane is not just a research airplane. It gathers together the benefits of all the research vertical airplanes that have gone before, and for this particular purpose is easily the most promising solution. The services have great plans for this if it goes ahead.

Q. Do you think that the Ryan approach holds more long-range promise than the big helicopters?

A. They both have their place. The big helicopter can never be fast. It has definite limitations, but it certainly has a great, broad field to be used in, particularly by the military. The helicopter can lift more for a given horsepower, but it can't go 500 to 600 miles an hour like a vertical take-off airplane will be able to.

Q. Do you think the combination automobile-airplane will ever become available to the average commuter?

A. I am not very optimistic about that. It's a lot of fun to think about it, but the trend hasn't been that way. We may, however, see continued development of private aircraft on a much broader basis than the aircraft we have today. It will take less skill, and performance characteristics on the slow side will be more compatible with safety for the average person to fly. If you compare this with small boating or yachting, you will come closer to what I think is actually going to happen.

We won't find airplanes in every garage. But it's conceivable if vertical take-off airplanes or helicopters can be made simple and inexpensive enough, a commuter might fly to a central "heliport," leave the plane there and take his second car or a cab to work.

Q. Getting to a different subject, do you think any of us will see the day when the average citizen will go into outer space?

A. I am not sure whether the average citizen will, but we will see some citizens going into space, there is no doubt about that.

Q. Since you came into the commercial industry in 1922, what were the real stand-out milestones as you look back at them?

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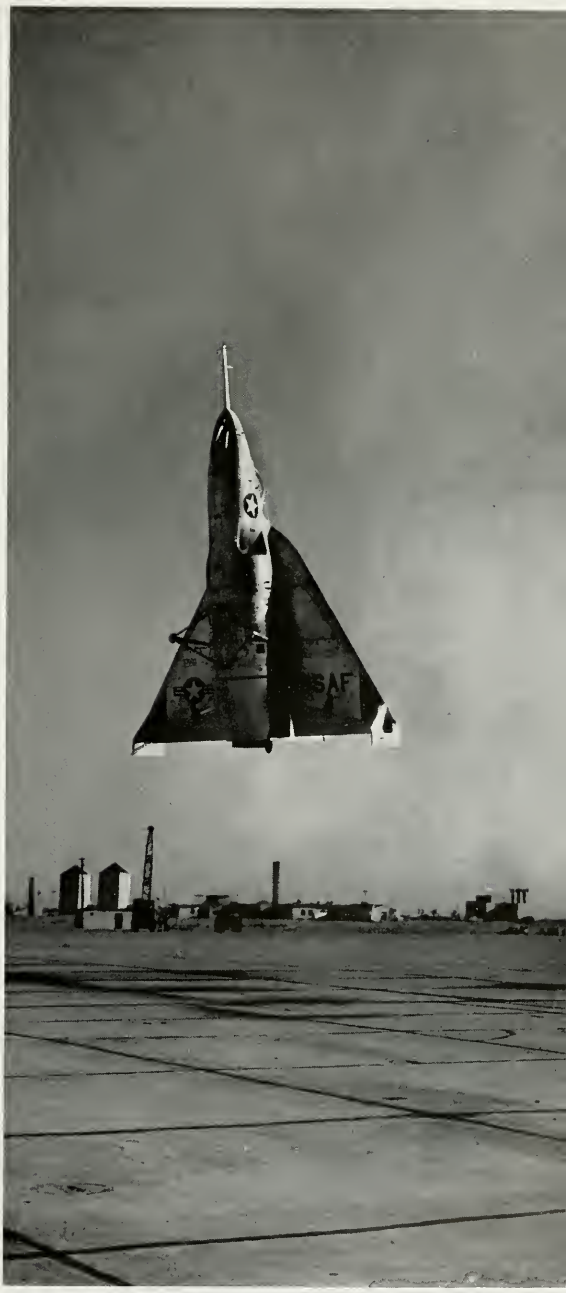


"If the Russians had built the first X-13 Vertijet, we would have been going hell-bent to catch up with them."

Translucent plastic Doppler radome for Ryan APN-97 automatic self-contained navigator transmits and emits radar impulses.

PLASTICS, stronger and lighter than aluminum, were virtually unknown to the aircraft industry a decade ago. Today, exceeding aluminum in pounds consumed, plastics are rapidly approaching glass production and consumption.

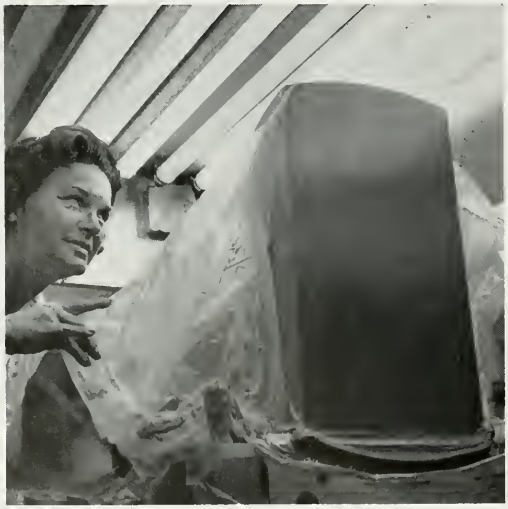
Engineers at Ryan welcomed the outstanding advantages which plastics provide the aircraft manufacturer. Simplicity and ease of fabrication of plastics automatically provide shorter lead time in making parts, tools and fixtures. Plastics also have the amazing capacity to reproduce complex contours and are inactive to shrinkage or heat distortion.

Continually evaluating new and sophisticated production methods, Ryan has rapidly become one of the largest plastic assemblers and fabricators among government suppliers. Servicing 14 large contracts, Ryan's streamlined plastic shop turns out more than 3500 complex components a month.

Ryan is the unchallenged leader in production and maintenance of parabolic shapes fabricated from plastic. Consuming some 4500 yards of 4-foot wide Volan fiberglass cloth every 30 days and 3,000 pounds of epoxy and polyester resins, the 55-man plastic crew fabricates a wide variety of aircraft and electronics components.

PLASTICS' PHENOME

Plastics specialist "sets up" navigator reflector unit under ultraviolet lamps for curing prior to baking in special ovens.



Reinforced layers of sheet Fiberglas are bonded together by resins in the fabrication of Ryan navigator radar reflector.

In the fabrication of complicated radomes and reflectors for self-contained navigation units, Ryan uses plastics extensively. The radomes and reflectors are carried aloft attached to aircraft and helicopters for transmission and emission of radar signals.

For the Ryan transonic Q-2C Firebee jet target missile, the plastic shop produces over 40 plastic components, including the nose cowling, oil sumps, battery covers and fuel tanks. Plastic provides the light weight and high strength necessary for components which attain transonic speeds and must withstand parachute recovery impacts.

Fabricated from metal, these components would require ribs and members for substantial reinforcement. This would mean extensive, time-consuming forming, cutting, welding, riveting and expensive machining.

Formed from plastic, all that is needed is a form of practically any material and various synthetic resins which are mixed with catalysts and hardened into required forms. The plastic is laid up against the form in liquid layers and reinforced with fiberglass until the required thickness is attained. Set up with special infrared and/or ultraviolet lamps and cured in special ovens, the component is then trimmed with diamond-tipped cutting tools and the smooth, seamless component is ready for assembly.

Probably the most fascinating phase in the fabrication of the plastic radar reflector — the "seeing eye" of radar — is the zinc spraying. In an isolated steel-shrouded room, tiny particles of zinc are literally blasted from a special spray gun which heats the particles to white-hot temperatures. The applicator, called the "zinc-man", is robed in a protective suit which resembles the space-suit of an astronaut. The zinc application is one of the most important phases of reflector production. The thin coating of zinc is required to pick up and send out the radar signals. Tolerances of plus or minus .003 of an inch must be maintained to provide for the insertion loss and reflected energy necessary for the electrical transmission through the "eye" of the radar unit.

The radome and reflector units are laid up with resins to provide the necessary flexibility to prevent the parting and shattering of the unit during extreme aerodynamic stresses occurring during ascent and descent. The units are laid up with .003 inch tolerances in a dust-free atmosphere. Since some of the epoxies and resins are perishable, refrigeration of 20 degrees to 45 degrees F. is provided.

(Continued on Page 26)

L PROGRESS

Spray gun heats particles to white-hot temperatures in application of thin coating of zinc on plastic radar reflector.

Nose cones are among more than 40 components produced by Ryan plastic shop for transonic Q-2C Firebee jet target missile.

Five Navy HSS-2 helicopters equipped with Ryan Doppler self-contained automatic navigational sets recently completed a 17-hour flight from Key West, Florida to Ream Field, San Diego, California to set an unofficial transcontinental speed record. Following is a report of this flight from the log of Lieutenant Bill Drake, pilot of helicopter No. 2 during "Operation DASH."

LT. DRAKE

"OPERATION DASH"

LAST minute grooming of the helicopters was completed on the evening of September 5. As we tucked the big birds in for the night, we were proud of the successful completion of the fleet introduction program. Here was the world's largest amphibious helicopter. A twin turbine, anti-submarine warfare weapons system with all-weather, around-the-clock capability. The first Navy helicopter that could locate, identify and destroy enemy submarines. And tomorrow we take them west to join the fleet.

The next morning at 7 a.m. the five giant helicopters lifted as a unit from the NAS Key West heliport into light advance breezes of the approaching Hurricane Carla. The Vee formation, led by Commander Bryan Eagan, circled once over the bay and saluted our hosts of the past four months with a 140 knot flyover at minimum altitude. Thus commenced our record flight from the southeasternmost point to the southwesternmost point of the United States.

Leg one traversed the picturesque Florida Keys to Marathon where we commenced the only overwater portion of the flight. Entering the Coastal Air Defense Identification Zone, we crossed the shallow gulf waters and scattered mangrove swamps at a pace-eating 135 knots to the mainland. Holding a comfortable vee formation, the Miami Beach skyline slipped by to the starboard and we approached the inland waterway to the north of Palm Beach.

From the Indian River past the space complex at Cape Canaveral and over the sands of Daytona to the broad St. Johns River, the flight angled inland to Navy Cecil Field. Sweeping over the long runways of this jet fighter base we performed a snappy carrier break, dropped our landing gear and landed with precision on the operations ramp. The radio was alive with exclamations of astonishment from the jet pilots as we taxied to the parking area. This debut of the down-trodden helo pilots into the realm of the jet-jockey society was marked with pride on the part of our ground crews who had landed a scant ten minutes ahead of us.

Time only for a quick cup of coffee, check on the weather and I filed our flight plan to Navy Ellyson. The birds were fueled and our thermos bottles topped off with fresh coffee. Our departure was on schedule and we commenced the actual transit of the continent at 1140 eastern standard time.

With clear skies forecast and our Doppler navigator doing all the work of pathfinding, we settled back to enjoy the flight lunches prepared at Cecil Field.

These Doppler navigators were a welcome contribution to the sophisticated system of the once lowly helicopter. Now, with Doppler in use, the helicopter can operate independently of shipboard or land-based radar control and landmarks, regardless of weather or visibility conditions. The pilot is relieved of the tedious job of continually estimating wind force and direction and making manual correction to the controls to compensate for these factors.

The pilot can now concentrate on keeping station, avoiding other ships and aircraft and executing the search and attack phases of his mission. Our flight data had proven to be amazingly accurate on the initial leg and we were

(Continued on Page 10)

In close formation, two of the five Navy Sikorsky HSS-2 helicopters that made record transcontinental run, soar over Louisiana.

Ryan Doppler equipment helped guide squadron to speed mark. Arrow points to navigator antenna as helicopter reaches destination.

confident that this data for the remaining legs would be equally reliable.

The arrival of the "Navy Jet Helo" flight at Ellyson was carried off with precision. A low formation pass followed by a carrier break from echelon to a rolling landing on the runway, made it obvious to all potential Navy helicopter pilots and their instructors that the big HSS-2 was on the scene. Much "hangar flying" resulted after the landing.

We thanked the C.O. for the rousing welcome received, filed our flight plan, and departed Ellyson 0400 the following morning. Metro service at Baton Rouge advised that ground fog was forming north to Alexandria, directly on our course. The sun had made its appearance and our first glimpse of the mighty Mississippi resembled the form of a giant brown python unwinding two thousand feet below. This was soon obscured by filmy layers of ground fog as the sun's warmth penetrated the cool moist air rising from the river banks. After crossing the Red River, we made our approach to Shreveport and our fueling stop at Barksdale Air Force Base.

Underway again, the broad expanse of east Texas slid from beneath us and soon the Dallas-Ft. Worth skyline appeared and stood dress parade to starboard as we bored westward to Abilene. A short leg stretching at Dyess AFB and we were again in the blue; a tightly knit formation of Navy Amphibious helicopters, somewhat out of our element over the dusty west Texas plains and surrounded by Air Force Bases. Meekness not being a characteristic of our brood, and firmly convinced that the best defense is a good offense, we shattered the relative calm at Webb Air Force Base and faded into the shimmering heat waves to the westward.

We were gradually forced to climb to lessen the effects of the thermal funnels that mounted from the sage scattered prairies and rocky table lands. After leaving an impression of the sound of our turbines at Midland and Wink we glimpsed the awesome gap of Guadalupe Pass at 12 o'clock high. A gradual climb to 6,500 feet while

maintaining our cruising ground speed, 130 knots, brought us to a safe altitude for our transit of this gateway to El Paso. Then a gentle but rapid descent introduced our flight of dusty travelers into the sun baked expanse of Biggs Air Force Base.

Servicing completed and a mounting anticipation of this last leg into Yuma, we created a few dust devils of our own tracking outbound from El Paso. Columbus, New Mexico in sight, then Gila Bend, Arizona and the back stretch into Yuma. At 1900, silhouetted against the setting sun, we peeled off over the runway at Yuma. This established an unofficial record for distance covered in one day by, not just one helicopter but the complete flight.

A warm welcome, a cold beer and a phone call to our families in San Diego put us all in the mood for a good night's sleep. Although the weeks of planning, the last minute preparations and the mild strain of the hours in the 'saddle' were behind us, we had to be on our mettle for the next morning's flight to Navy Ream in Imperial Beach, near San Diego.

Over the desert now, with our twin turbines humming "California Here We Come," the trace on our ASA 13 A Navigational plotters tracked us to NAAS El Centro where Vice Admiral Ekstrom embarked as Commander Eagan's co-pilot for the jump over the rocky Laguna Mountains. Our flight was picked up by the Radar Air Traffic Control Center located at Miramar as we approached Campo. With radar monitoring the area and our Doppler radar feeding ground speed and wind data into the navigational system the network of TACAN and low frequency ranges and beacons across the country seem akin to unnecessary luxuries.

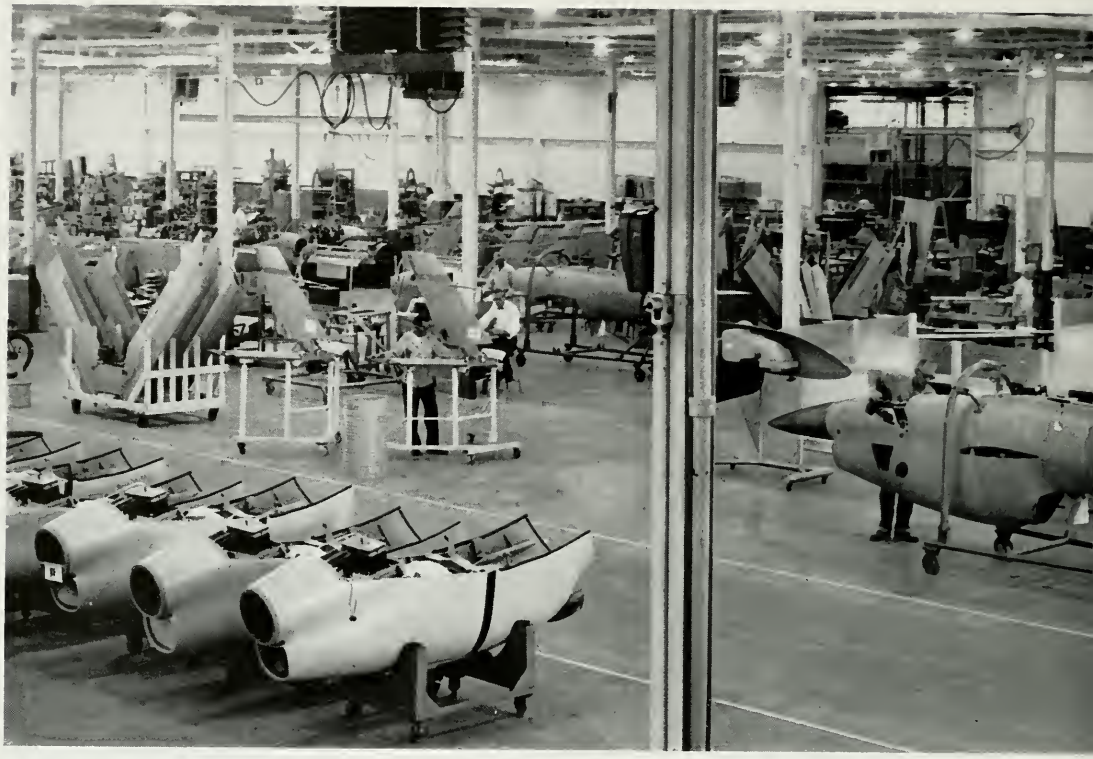
As the glittering waters of the Pacific hove into view, the comfortable feeling of home permeated the atmosphere and relaxed the tense muscles of the flight crews. The low thundering sweep over North Island, the site of unnumbered Naval Aviation 'Firsts', followed by a left climbing turn abeam Point Loma, placed us in position to

(Continued on Page 26)

Peeling off like jet fighters, HSS-2's thrill spectators at end of cross-country delivery flight.

Ryan Doppler antenna is pointed out by Owen S. Olds of Ryan Electronics, to Vice Adm. C. E. Ekstrom, T. C. Ryan, Jack Conner of Sikorsky Aircraft, and Igor I. Sikorsky.

Aviation pioneer Sikorsky lauds crews for fastest helicopter crossing of United States ever made.



FORMULA

Proximity of parts ta assembly jigs at Ryan "Drone Center" expedites work on the empennage and vertical stabilizer line.

THE formula for maximum production efficiency in an assembly line operation is a combination of ready accessibility of parts, plenty of elbow room, and pleasant surroundings.

These ingredients are applied in the new Q-2C Firebee "Drone Center" at Ryan Aeronautical Company's San Diego plant, where a smooth functional flow is achieved in an attractive, spacious environment.

Creation of the "Drone Center" was the result of increasing Firebee business which made the move to a larger area a necessity, and provided an ideal opportunity to "showcase" one of Ryan's outstanding proprietary products.

Planning of the "Drone Center" was a team effort of production, quality control, production control, production engineering, plant engineering, and

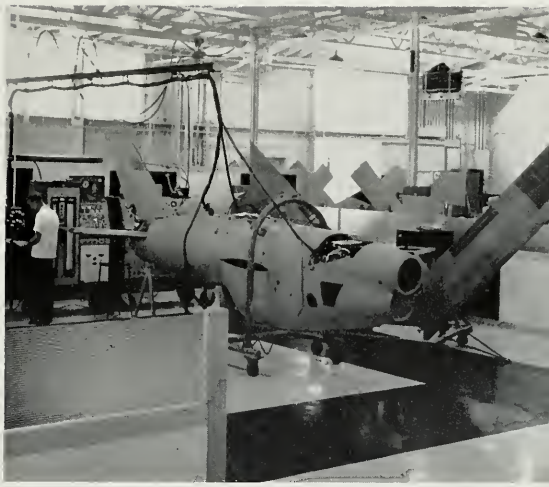
FOR EFFICIENCY

an industrial design consultant—all under the guidance of the Industrial Engineering Department.

In the newly established Q-2C production area, these are the major achievements:

- 1—Smooth flow of materials.
- 2—Attractive environment. Walls have been painted two shades of blue; jigs and fixtures are a bright blue; rolling objects are light yellow; and objects which must be treated with caution are carrot-colored. The harmonious color scheme, suggested by the industrial consultant on the basis of extensive experience in industrial plants throughout the country, enhances worker effectiveness.
- 3—Control functions are integrated into the area, rather than maintained in separate offices elsewhere. Enclosed by portable "Aluma-Walls" is the

(Continued on Page 25)



Focal point of the Q-2C production area is the test center, where completed Firebees undergo final functional checkouts.

Jet engine build-up for Q-2C Firebees is facilitated by quick access to the ports shown in foreground on rack and pegboard.

DOPPLER NAVIGATION FOR SUPERSONIC TRANSPORTS

Excerpted from speech given by Leland S. Reel, Principal Engineer, Ryan Electronics, before Western Region of the Institute of Navigation.

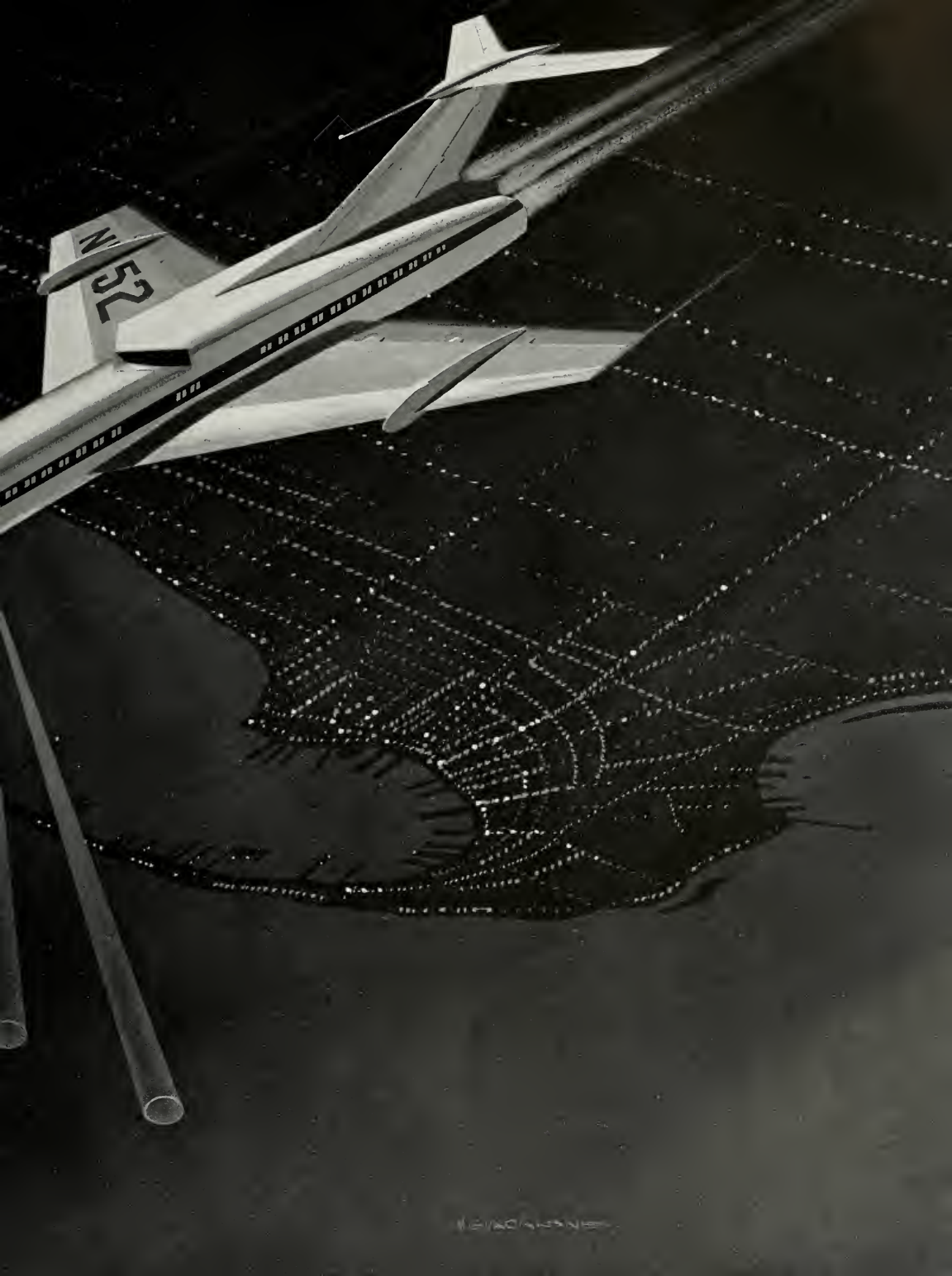
The requirement for a more complete and more accurate flight control system in supersonic transports becomes apparent since the instrumentation and methods now used in subsonic craft will probably prove inadequate in high performance aircraft.

Imagine . . . a sky full of supersonic transports streaking from point to point at speeds up to Mach 3 and faster. New York to Paris in less than 120 minutes. Now, consider the flight control system employed by current subsonic craft in comparison to the control system needed by their supersonic descendants.

Today's subsonic aircraft depend on data from land-based radio and radar installations; a vertical gyroscope for pitch and roll measurements, and a magnetic compass for aircraft heading angle. Some portions of the flight con-

(Continued on Page 29)

Doppler radar radiates beams of microwave energy toward the ground and receives reflected energy back from directions of the original radiation.


N52

Artist's sketch shows how Flex Wing towed glider, supporting heavy load, could multiply cargo-carrying capacity of Army helicopter.

NEW USES FOR FLEX WING

Unmanned towed glider is another application

THE Flex Wing as a manned, powered "flying test bed" . . .

The Flex Wing as a recovery "carrier" of the Saturn space vehicle first stage booster . . .

And now the Flex Wing as an unmanned towed glider . . .

Third in the series of ever-widening applications of the unique Ryan flexible wing aircraft has been disclosed with announcement of a study contract by the Army Transportation Research Command.

In further advancement of the Flex Wing's "mobility breakthrough" concept, the Army has ordered Ryan to perform prototype engineering for several configurations of towed logistics gliders capable of multiplying as much as six times the cargo carrying capacity of its planes. After the study period, fabrication of prototypes of such gliders may be initiated.

(Continued on Page 27)

THREE of America's major aerospace companies have formed an engineering and fabrication team to develop and build a tri-service military transport capable of vertical take-offs and landings.

Five experimental tilt-wing VTOL prototypes will be designed and built by Ling-Temco-Vought of Dallas, Texas; Hiller Aircraft Corporation of Palo Alto, California; and Ryan Aeronautical Company of San Diego, California.

The team was selected following an intensive design competition involving nearly 20 leading aerospace firms.

The tri-service program may exceed $70 million, with the Air Force assuming management responsibility. Each of the three services — the Air Force, Navy and Army will contribute $7 million for the fiscal years of 1961 and 1962, and will share remainder of the costs over a four-year period.

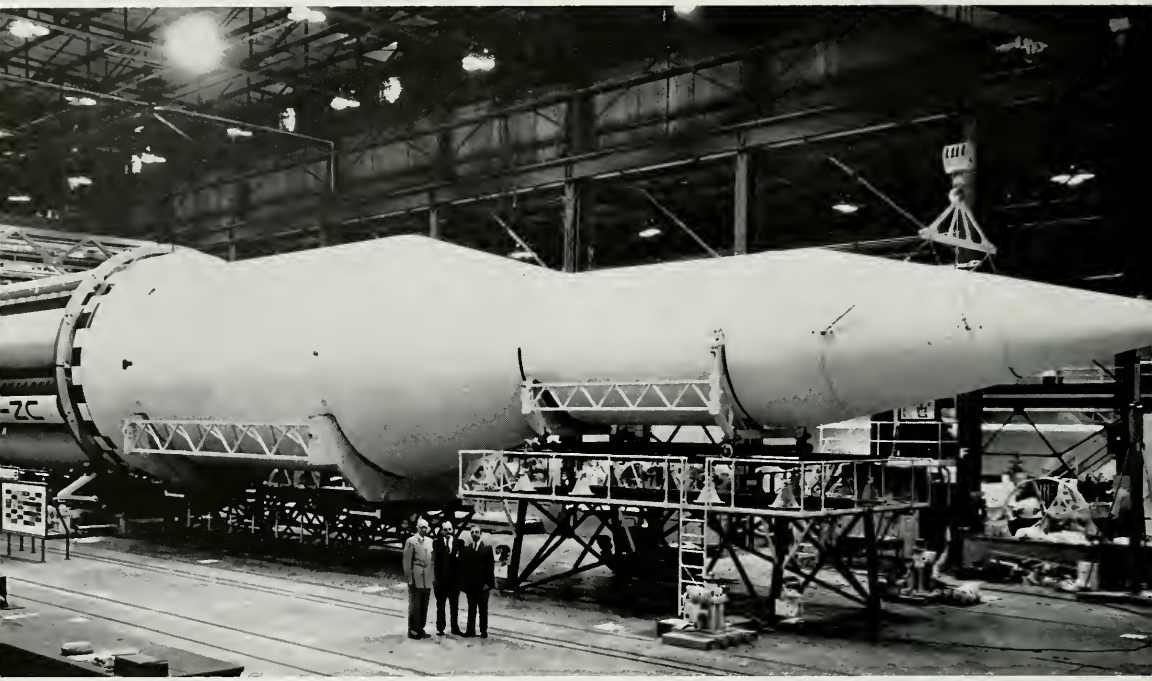
(Continued on Page 27)

Plenty of room for 32 troops, some of whom are pictured in VTOL mockup, will be provided in new military transport.

TILT-WING TRANSPORT

Three-company team to build tri-service VTOL

Heavy equipment will be carried in tri-service VTOL transport being developed by Ryan, Ling-Temco-Vought and Hiller aero firms.



Ryan Electronics will design radar system for Saturn space vehicle capable of recording altitude measurements up to 250 miles.

SPACE ELECTRONICS

Saturn and Surveyor to carry Ryan radar altimeters

RYAN Electronics is participating in two of the major space projects of the National Aeronautics and Space Administration through award of contracts for the design, development and fabrication of radar altimeters for the Saturn space vehicle and the Surveyor lunar soft landing vehicles.

In addition, Ryan will provide the Doppler velocity sensor equipment for the Surveyor.

The $450,000 Saturn contract is directly from NASA's George C. Marshall Space Flight Center, Huntsville, Alabama, while the $2 million order in the Surveyor project is from Hughes Aircraft Company, which is developing the spacecraft under a contract from the Jet Propulsion Laboratory of the California Institute of Technology.

Under the agreement with NASA, Ryan Electronics will develop a radar system capable of recording altitude measurements up to 250 miles. Although radar altimeters are being used in current rockets, none meet the long-range requirements of the Saturn program.

The Ryan Saturn radar altimeter will measure the travel time of a single

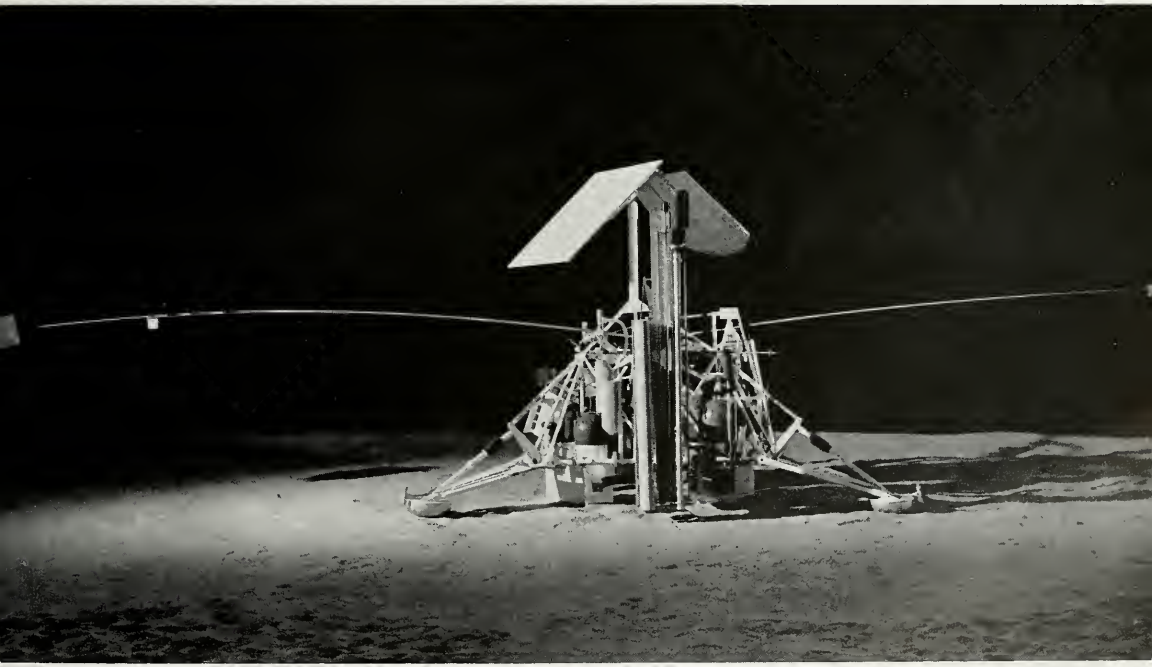
radar pulse transmitted from the vehicle to the ocean (in this application) and reflected back to the vehicle. Weighing only some 16 pounds, the compact unit will be employed in later multi-stage firing of the 1.5 million pound thrust Saturn.

The first Saturn booster carrying two inert upper stages will be launched by the Marshall Center from Cape Canaveral, Florida. Radar altimeters will not be needed in early Saturn booster flight tests where retrievals of low altitude of about 100 miles will permit land-based and shipboard track.

Saturn, a project of NASA under direction of Dr. Wernher von Braun, represents the largest space vehicle under development in the United States. It will be capable of sending payloads of several tons into orbit, to the moon, and into deep space. One of the main purposes of Saturn is manned space exploration leading to lunar landings of men and equipment within this decade.

The Surveyor spacecraft is the second of a series planned by JPL for moon landings. It involves a soft landing of an instrumented vehicle on the surface of the moon.

In addition to the Saturn and Surveyor projects, Ryan is involved in a number of other space efforts, including studies aimed at solving such problems as rendezvous terminal guidance, antisatellite terminal guidance, satellite vertical reference, gravitation control and communication antennas.



Soft landing of a Surveyor vehicle on the moon will be assisted by Ryan Electronics radar altimeter and velocity sensor equipment.

WILLIAM TELL 61

THE ultimate target for a weapons system is the enemy. William Tell 1961 was the closest approach to actual enemy-intercept situations which could be simulated. It was the *first* A—Century Series weapons meet, *first* to use ground-launched jet targets, *first* to use SAGE (Semi-automatic Ground Environment) control and *first* to use infrared photographic coverage. It was the *third* Air Force Interceptor Weapons Meet to select the Ryan Firebee as the sole target. Firebees pioneered the use of free-flying jet targets at Project William Tell (1958) and William Tell II (1959).

Pitted against 110 Firebees at William Tell 1961 were 13 top Air Defense teams flying Convair F-106 (4 teams), McDonnell F-101B (4 teams) and Convair F-102A (5 teams) interceptors. They were scrambled for high (above 50,000 feet) and low (below 15,000 feet) missions under both day and night conditions. They fired deadly MB-1T Genie rockets and Falcon GAR-1D, GAR-2A and GAR-4A missiles. An average ten missions a day were flown by Firebees at this ten-day weapons meet. SAGE automatic controls from the Montgomery Air Defense Sector vectored the F-101B and F-106 aircraft to the "enemy" Firebee targets through data link communications. F-102As were scrambled with manual controls and voice communications.

Firebees not only drew the fire of

Ryan Q-2C Firebee targets challenged Air Force's best missile-firing interceptors in world-wide weapons meet at Tyndall AFB, Florida.

the interceptors but scored the results in mid-air, with fast electronics systems of PARAMI and MATTS. A running record of hits, misses and near-misses was instantly transmitted to ground scorekeepers. Firebees were ground-launched (with JATO bottles) and air-launched (from GC-130 aircraft) and recovered by parachute.

These fast, elusive, high-flying "bull's-eyes" are the most widely used jet targets for evaluating air-to-air and ground-to-air missiles and rockets. They fly over 600 mph, above 50,000 feet and for durations of well over one hour. Firebees have made thousands of successful flights, with recoveries over land and sea by parachute systems.

At William Tell 1961, Firebees were ground-launched by the 4756th Drone Squadron from launching stands near the complex of Tyndall Air Force Base. They were launched out to sea to fly around a race-course type pattern over the Gulf of Mexico. A secondary launching method was available by means of GC-130 aircraft which can carry four Firebees aloft and air-launch them at altitudes from 10,000 to 20,000 feet. They have established a new standard of reliability for meeting the exacting demands of weapons meet performance. A typical Firebee mission goes like this:

Shortly before "on range" time, the Florida sun splashes over the bright orange paint of two Ryan Firebee target drones, resting in their ground launch racks, pointed out to sea. Preflight checks have been completed, the targets' 22,000 lb. thrust JATO bottles have been attached and electric igniters installed. The jet engine of target No. 1 is started and begins to whine as it gathers rpm. Behind a heavy-walled enclosure, the launch control operator presses a button. The bottle fires and the eager Firebee leaps into flight, breaking the restraining tie-back and streaming a plume of white smoke.

In seconds, the Firebee is making 200 knots, the JATO falls away and the target climbs quickly, a fluorescent speck against the blue sky. Radar antennas on the ground pulse into action, lock on the drone, as ground control "beeps" commands - "turn" - "climb" - "straight and level" - "high speed" at 30,000 feet.

Firebees were recovered repeatedly from Gulf of Mexico by Air Force helicopters and flown back to the base for further use as targets.

The Firebee enters the firing range. Ground Control Intercept (GCI) issues commands to the F-106, F-101B or F-102A aircraft to SCRAMBLE. Air Force fighters smash their way into the air for the search, inter-

(Continued on Page 26)

JACKSON ASSUMES PRESIDENCY: RYAN CONTINUES AS CHAIRMAN

Robert C. Jackson assumed the duties of President of Ryan Aeronautical Company, effective November 1. T. Claude Ryan, who has held the positions of President and Chairman, continues as Chairman of the Board and Chief Executive Officer.

Mr. Jackson has been the company's Executive Vice President for the past two years. Duties of the chief executive officer and chief operating officer, both formerly filled by the President and Chairman, are now divided between the two positions.

Mr. Jackson, who has been associated with the Ryan Aeronautical Company since his appointment as Director in 1957, was graduated from Stanford University in 1929. After advanced studies at Harvard Graduate School of Business, he returned to Stanford and there obtained his Masters Degree at the Graduate School of Business. In 1934 he became a Certified Public Accountant in California.

Before joining the Ryan organization, Mr. Jackson had extensive experience as an industrial and business executive in Southern California. Following work with Lybrand, Ross Bros. & Montgomery as a public accountant, he was associated with the Security First National Bank and with the West Shore Company.

As Vice President and General Manager of West Shore, Mr. Jackson managed and operated subsidiary companies in the fields of construction, investment, machine tools, petroleum production, and nuclear instrumentation.

ROBERT C. JACKSON

Commissioned as a Second Lieutenant in the Field Artillery in 1929, Mr. Jackson took part in the invasion of North Africa, Italy and Southern France.

Prior to war's end he was ordered back from Germany to the Pentagon and, as a Lieutenant Colonel, headed up the War Department's interim finance operations for contract termination. He received the Bronze Star, four Battle Stars and other theater decorations in the European campaign.

Interview: Space Age

(Continued from Page 5)

A. The development of the first twin-engine airplane; the award of airmail contacts that sparked the development of the airline system in the United States; the four-engine transports, and introduction of jet propulsion.

Q. Some people in the Pentagon believe manned bombers and interceptors are on their way out, and will be replaced by armed satellites, rockets, and so on. Then there is the other group, of which General LeMay is one, who believe that the manned bomber and interceptor will be here for the next 10 to 20 years.

A. I would lean more to General LeMay's thinking. I believe that the recent Russian Air Show may have quite an effect on the thinking of some of our military people, when they see that the Russians have been doing a lot about developing their manned aircraft.

Q. Do you think the manned airplane industry may make a comeback?

A. Yes, if you call it a comeback, or not just die as fast as it has been. Things got out of balance when we began depending too much on ICBM's as being the whole answer. It takes a balance between manned aircraft and missiles.

We are inclined to think that something is really terrific, if the Russians do it first. If we do it first, nobody gives it much attention. If the Russians had built the X-13 Vertijet, (world's first pure-jet VTOL, developed by Ryan for Air Force—Ed.), we would have been going hell-bent to try to catch up with them.

I understand at this last air show they showed a vertical take-off plane, so maybe they've put a new spark of life in this whole thing.

Q. What about nuclear-powered planes —what would their mission be?

A. My impression is that the original concept was that this could be sort of an aerial aircraft carrier, a missile lofter. You could fool around up there and go any place you wanted to go, and certainly the Russians would have trouble knowing where it would be. It would be the same thing in the air that submarines are in the water.

Q. Do you think overall that our Navy and industry are ahead of Russia?

A. In certain phases they might be ahead, but we are ahead of them when it is all added together.

Q. How important do you think it is for the United States to be first out with a supersonic airliner and to what degree do you think the Federal government should participate in such a program?

A. I can't quite see where the supersonic transport, except for prestige purposes, is necessarily the best place to invest all of the necessary tremendous effort.

Q. Could part of this be invested in a B-70 program?

A. Definitely. It seems it would be a very dangerous thing not to go ahead with that project, with the start we've got on it. If we thought that Russia had a development coming along similar to that, we'd break our necks to try to get ahead of them.

Q. What do you think the future is for the small and moderate-sized aviation corporation? Will it have commercial limitations?

A. No, I don't think so. For example, we would be handicapped if we were very much smaller, but I think we would be handicapped if we were real large, too, for the type of work we're doing. By building target drone missiles, electronic systems and many of the highly scientific things that don't involve tremendous size and require big storage or handling room, the smaller company is best.

ACTIVITY in the exhaust manifold production area of Ryan Aeronautical Company's San Diego plant during 1961 was the greatest since the Korean War, as assembly lines turned out thousands of collector system components for piston-engined aircraft.

Major projects were for the Air Force B-50 series of weather, reconnaissance and tanker planes; and the C-124 Globemaster transports.

The B-50 contract, exceeding $2 million, was for replacement of exhaust systems built by Ryan in the early 1950's. The C-124 work is extension of a program under way for several years.

Ryan was the original supplier of the B-50 exhaust systems, which demonstrated such durability that production of new parts had been unnecessary for nearly a decade, during which tools were retained in useable condition at the San Diego plant.

Spurt in production of exhaust manifolds at Ryan's San Diego plant featured 102-foot long conveyor belt, which expedited the flow of B-50 manifold parts.

"HOT PARTS" REVIVAL

To meet the demands of the B-50 contract, large numbers of experienced manifold assemblers, welders and others were recalled to form again the efficient teams that established Ryan as one of the world's leading builders of stainless steel "hot parts".

Reactivated was a 102-foot long conveyor belt that expedited the flow of B-50 manifold parts from station to station. The exhaust system units glistened in a green ceramic coating that provides longer life through heat and corrosion resistance. Ryan was one of the pioneers of this process, which along with the manifold design and manufacturing methods gave the original B-50 exhaust systems a record of long service time and a minimum of maintenance and repairs.

For the C-124, Ryan has been manufacturing new replacement exhaust systems and overhauling existing systems as requirements develop.

Production of exhaust systems for Douglas C-124 Globemasters, under way for many years, received fresh impetus with new contract.

PROPELLER-DRIVEN planes and jets . . . military aircraft and commercial transports . . . conventional configurations and tail-standing VTOL's . . . landbased planes and flying boats . . . the very slow and the supersonic . . . missiles . . . drones . . . gliders . . . electronic devices . . .

All these and more comprise the wide spectrum of more than 33 event-filled years in the engineering career of SAE's 1962 President, Frank W. Fink,

FRANK W. FINK NEW S.A.E. PRESIDENT

Elected to the Presidency of one of America's foremost professional organizations, the 25,000-member Society of Automotive Engineers, Frank W. Fink, Ryan Aeronautical Company Vice President-Engineering and Products, will assume office January 1, 1962 for a one-year term, climaxing a long period of dedicated service to the SAE. His ascendancy to this high post is national recognition of an outstanding career in aeronautical engineering.

Ryan Aeronautical Company Vice President-Engineering and Products.

From the day in 1928 he joined the Curtiss Aeroplane and Motor Company in Garden City, Long Island in his first job after graduating from the University of Colorado with a Bachelor of Science degree in Mechanical Engineering, Fink has been associated with some of the most significant developments in the spectacular progress of aviation.

And the deeper space is penetrated, and the greater the speeds achieved, the more unshaken is Fink's belief that man will remain master of his far-ranging vehicles.

"The military will always need manned aircraft for limited warfare applications," he observed.

"Man will not be satisfied in merely sending out space probes. Comdr. Shepard is the forerunner of many who will travel through space in manned vehicles.

"And commercial aviation will continue to grow in both the public transportation and the private and business fields."

A native of Philadelphia, Fink was an infant when his family moved to Denver, where his father was a certified public accountant.

Mechanical and electrical gadgets fascinated him in childhood, and his interest turned to aviation in World War I, although he was too young for the armed forces. In high school he decided to devote his life to engineering.

After 7 years with Curtiss and its successor firm, Curtiss-Wright, Fink joined Consolidated Aircraft Co. (now Convair division of General Dynamics Corp.) in 1935, the year its operations were transferred from Buffalo, N.Y. to San Diego, California.

In his 20 years at Convair, during which he rose to the post of Chief Engineer, he directed the design of the Convair Liner, the Sea Dart water-based jet fighter, the Tradewind turboprop flying boat, the Navy Pogo Stick (world's first VTOL), the F-102 and F-106 supersonic interceptors, and participated in the original Terrier and Atlas missile programs. Much of the preliminary work leading to the Convair 880 jet commercial transport was performed under his direction.

During World War II, he was Chief Production Engineer for Convair on the B-24 Liberator bomber, and the Catalina and Coronado flying boats, three versatile "workhorse" type aircraft that helped swing the tide to victory.

In 1955, Fink came to Ryan as Vice President and Chief Engineer. At Ryan he has helped direct development of such advanced programs as the X-13 Vertijet, world's first pure jet VTOL; the VZ-3RY deflected slipstream propeller-driven V/STOL Vertiplane; the Q-2 series of high speed Firebee jet target drones; the Vertifan (submerged fan-in-wing) VTOL concept; boundary layer control studies; and the current "Flex Wing," a unique new class of flight vehicles using wings of cloth or other flexible material. He organized the electronic engineering section into a new Electronic Division in 1957, and acted as Division Manager for the first year.

The new SAE President holds several patents, including the unusual stairway which extends from and retracts into the front of the Convair Liner

(Continued on Next Page)

New S. A. E. President

(Continued from Page 24)

transport, providing a self-contained ramp for passenger loading and unloading.

Frank Fink's affiliations with the SAE dates back to 1944. He was elected first chairman of the newly organized San Diego Section in 1946, and every year since has held key posts in the national organization. He has served twice as General Chairman of the National Aeronautics Meeting in Los Angeles (1947 and 1951), and was chairman in 1957 of the Wright Brothers Medal Board of Award.

Frank was a National Counselor in 1948-49, a Vice President in 1954 and has served on both the Technical Board and the Engineering Activity Board. He was also a member of the 1961 Board of Directors and the Executive Committee, and has served in numerous other capacities.

Fink also is a Fellow of the Institute of Aerospace Sciences, of which organization he is a past San Diego Section chairman, and a member of several other technical and business organizations. In addition, he is a director of the Southern California Industry Education Council and on the board of Space Logistics, Inc.

In San Diego, his civic duties include service as a director on the Boards of the Crippled Children's Society and the Child Guidance Clinic.

He relaxes by reading, playing the electric organ, and gardening in the large yard of his Pt. Loma home, overlooking San Diego Bay. The family's weekend retreat is a three-room frame cabin he built at Idyllwild, in the San Bernardino Mountains of Southern California.

Frank and his wife Janet have a 16-year old daughter, Susan, and two sons, James and John. James, also a member of SAE, who during the past year followed in his father's footsteps as San Diego Section Chairman of I.A.S., joined Ryan recently as Project Engineer—Tactical Systems, and John is a supervisor in the material estimating department at Convair.

Fink foresees an acceleration of interest in the development of V/STOL concepts.

"Concentration of effort aimed at increased performance of aircraft and missiles has inhibited V/STOL programs, but the pattern of progress in the military and commercial transport fields points to the need for such aircraft not only for feeder line service between cities or remote areas, but also to provide short take-off capabilities for high speed planes," he says.

"Various new ideas in the VTOL field are being profitably explored, including tilt wing, deflected slipstream, and submerged fan-in-wing."

Fink believes that an engineer's morale in any organization remains high "if he is kept busy on projects in which he himself is intensely interested and in which he believes the company has a high degree of interest."

An engineer must guard against becoming hidebound in his thinking. "Experience is invaluable, but it must represent the continued acquisition of new knowledge," Fink declares. "The engineer's mind must always be receptive to new ideas."

In this respect, the SAE is invaluable to the engineer as he is stimulated by interaction of ideas and experiences of fellow members, Fink points out.

"This is a unique organization in that it covers the entire technical scope of automotive ground and flight vehicles," the new president comments. "It provides a perpetual forum in which members can expand the scope of their interests and knowledge. It helps us avoid that fatal pitfall — the narrow viewpoint."

New Engineering Director Named

T. H. Beck has been named Director of Engineering for Ryan Aerospace, Frank W. Fink, Ryan Aeronautical Company Vice President, announced recently.

T. H. Beck

Beck is a veteran of more than 30 years' experience in aeronautical engineering. He began his Ryan duties in 1959 as Engineering Manager-Army Aircraft, and, more recently, was Engineering Manager-Product Development. Beck attended Case Institute of Technology and Fenn College, both at Cleveland, Ohio; and the University of Southern California and U.C.L.A.

Since starting as an apprentice at the Great Lakes Aircraft Co. in 1929, Beck has been associated with Douglas, Northrop, North American, Convair, and prior to joining Ryan was with Fairchild Aircraft Corp. for nearly 12 years.

At Fairchild, Beck rose to Engineering Manager, supervising all product engineering operations for the C-119, C-123, B-52, F-27, M-230 and M-252 projects.

Reporting to the new Aerospace Director of Engineering are the Chief Engineer, Engineering Controls Administrator and Program Managers for the Tri-Service Transport, Firebee Drone Projects, Flex Wing and Vertifan.

Formula for Efficiency

(Continued from Page 13)

project office. Similarly enclosed in the midst of the production area is the functional test center, which has a vinyl tile floor and a dramatic black and white color scheme highlighting each completed Firebee undergoing final tests.

- 4—One hundred percent line stocking. The storeroom concept has been eliminated with a time-saving stocking of all parts adjacent to the working stations, on specially designed racks and pegboards. This reduces parts handling by providing ready accessibility.
- 5—Movement of personnel and parts is improved through creation of 8-foot wide aisles.
- 6—Lighting is improved by installation of new bulbs, and white paint on the ceiling—the combination doubling the effective light at the working surface.

Plastics' Phenomenal Progress

(Continued from Page 7)

According to Ray Fuller, plastic shop foreman, Ryan is foremost in the production of radomes and reflector components with six different types of radomes and five reflector configurations in production, plus several others in development.

One of the most advanced parts fabricated from plastic is the complex nose cowling for the Ryan Q-2C Firebee transonic jet target missile. Containing more than 65 separate parts, most of which are intricate in design, the cowling must travel through a dozen different fabrication phases.

Assembled from fiberglass material, polyester resins and catalysts, the Q-2C nose cowling is laid up and fabricated with tolerances of plus or minus .010 of an inch. Formed into shape from a dozen separate layers of fiberglass material, the nose cowling is set and cooked in an oven heated to 270 degrees F. for final curing.

More than 1100 Q-2C components travel from the Ryan plastic shop every month destined for a dozen military bases around the world. The mushrooming Ryan plastics operation under the direction of Robert Guyer, Project Superintendent, is a closely coordinated activity consisting of production engineering, industrial engineering, production control, inspection and manufacturing personnel.

Typical of Ryan's extensive design projects is the utilization of new and advanced plastics in subsonic aircraft and missiles. Taking advantage of plastics' amazing ability to escape detection from radar and other detection devices, Ryan engineers are developing new materials and processes for the application of plastics to modern supersonic aircraft and missiles.

William Tell 1961

(Continued from Page 21)

cept and "kill" of the "enemy" target. GCI vectors the interceptors to precise position as they zoom to altitude, to save precious time. Airborne radars scan space, lock on the target. Pilots press missile firing buttons and wait for automatic firing as the range closes.

"WHOOSH"

In a stream of fire and smoke a deadly missile or rocket is unleashed at the elusive Firebee — out of sight and pushing Mach 1. As the ball of fire bores in, the Firebee picks up the missile's range and transmits a running record of its fast-closing distance to the ground scoring station. With electronic speed and precision, the "miss-distance" is recorded as the missile streaks by and boils out to sea. Because the target is a "stand-in" for larger enemy aircraft, a "hit" can be registered even t h o u g h the bright "bird" is not touched. Or, the Firebee might be clobbered by the supersonic collision.

If airworthy, (Firebees have flown on with shrapnel-ridden fuselages and broken turbine blades), the drone will stay aloft for about one hour while more firing runs are made against it. Then, the signal for "parachute" will be commanded and the two-stage system will blossom out, jerking the target up like a horse reined in. As the drone floats gently down to earth or sea, an Air Force H-37 helicopter circles to retrieve it and return it to base where it will be reconditioned to fly again. Many Firebees have made more than 15 flights and recoveries.

"Operation Dash"

(Continued from Page 11)

cross the Silver Strand, South San Diego Bay and enter the Ream Field area from the east. After sweeping the runway, the flight shifted to right echelon climbing to 500 feet while making a 360 degree turn to port and again roared past the landing area lowering the wheels in unison and executing a smart carrier break-up to a landing on spots adjacent to the welcoming group. Taxiing and shut-down was accomplished with a smooth coordination and routine efficiency that had been the hallmark of this entire operation from its conception to the successful completion.

On hand to herald this first delivery of the new twin-turbine helicopters to operational Navy s q u a d r o n s were members of local and national press, radio and television outlets, waiting families, military and civilian dignitaries, and fellow helo pilots. Representatives of Sikorsky Aircraft including retired engineering manager Igor I. Sikorsky, builders of the HSS-2; Ryan representatives, both from Electronics and the p a r e n t Ryan Aeronautical Company, including T. Claude Ryan, Chairman of the Board and Chief Executive Officer, Ryan Aeronautical Co.; Owen S. Olds, Vice President, Engineering/Sales, Ryan Electronics; William Wagner, Vice President, Public and Personnel Relations, Ryan Aeronautical Co.; and Don Fairchilds, Manager of Public Relations, Ryan Electronics, congratulated us on our successful flight.

All the personnel involved in this undertaking, be they the flight crews, servicing crews, airways personnel or the builders of the numerous components that make up this complete weapons system may take justifiable pride in the s u c c e s s of "OPERATION DASH."

(Editor's note)

Doppler navigational sets (AN/APN-130) mentioned throughout this report were conceived and manufactured by Ryan Electronics and are standard equipment in the HSS-2 helicopter.

$9 Million In Navigator Orders

The U.S. Navy has ordered more than $8,300,000 worth of airborne navigation systems, spares and support material from Ryan Electronics, the largest producer of continuous-wave Doppler navigation equipment for both fixed-wing and rotary-wing aircraft.

These automatic navigators are in quantity production for a wide variety of military aircraft and helicopters, reconnaissance and attack aircraft, airborne early warning and certain special purpose aircraft.

From Westland Aircraft, Ltd., of Yeovil, England, Ryan Electronics has also received a $633,000 purchase order for AN/APN-97A Doppler navigation sets being installed in the company's Wessex helicopter.

The AN/APN-97A is designed primarily as a ground velocity indicator for helicopters, providing the manual or automatic means for the pilot to maintain his aircraft in a precise hover under all conditions of visibility.

The completely self-contained set functions anywhere in the world without reliance on ground stations, wind estimates, or true air speed data, and automatically and continuously measures and displays heading speed, drift speed, and vertical speed.

New Uses for Flex Wing

(Continued from Page 16)

Meanwhile, for other agencies, Ryan is working on at least two other Flex Wing contracts which have not yet been made public.

And testing of the first Flex Wing, built by Ryan to demonstrate fundamental functional and aerodynamic characteristics, is proceeding under Army Transportation Research Command auspices in the San Diego area.

Also being conducted is a contract with the National Aeronautics and Space Administration to study adaptability of the Flex Wing for recovery of the Saturn space vehicle first stage booster, bringing it gently to a predetermined landing site by means of an unmanned glider.

In the new study contract awarded by the Army Transportation Research Command, the Flex Wing would be towed behind a helicopter or fixed-wing plane, with payloads of as great as 10,000 pounds and more suspended beneath the glider. All types of supplies, weapons and fuel could be airlifted in this manner to provide speedy logistics support to Army units in the field.

Based on an original concept by Francis M. Rogallo of NASA, the Flex Wing, unlike the rigid surface of conventional wings, consists of a membrane of flexible, plastic-coated material attached to a keel and leading edge members so as to form an arrow- or V-shaped, kite-like surface.

The flexible wing offers an extremely lightweight, large aerodynamic lift surface and a simplified control system using center-of-gravity shift instead of displacement of conventional control surfaces.

Designed to be folded into a compact package, it can be quickly deployed for varied missions performed by both manned and unmanned vehicles, powered or unpowered. These may vary from small, powered reconnaissance drones maneuvered by remote control, to huge, unpowered wings capable of recovering payloads and rocket boosters of 50 tons or more.

The wing has been tested, in free flight and wind tunnels, from low subsonic velocity to speeds of Mach 4.9 and from low altitudes to 200,000 feet.

The new Army study contract and the still unrevealed Flex Wing projects recall the comment made recently by a top-level spokesman of U.S. Army Aviation:

"Applications of the flexible wing are limited only by the imagination of military planners."

Tilt-Wing Transport

(Continued from Page 17)

In addition, the three services have under consideration a supplementary research program to evaluate other concepts of VTOL aircraft based on the designs submitted in the competition. If one or more additional configurations is selected for further development, the total program amount may exceed $100 million.

Ling-Temco-Vought will serve as prime contractor, associated with Hiller and Ryan in the engineering and fabrication of the tilt-wing prototypes.

Ryan will design, tool and construct the fuselage aft section assembly, including the cargo ramp, fin, rudder, horizontal tail, and tail boom. Ryan also will design, tool and construct the wing and engine mounts and nacelles, including access doors, engine inlet and oil cooler screens, and miscellaneous wiring and de-icing controls.

Specialized Ryan engineering personnel will assist not only in the design, but also in the ground and flight test program at the Ling-Temco-Vought plant in Dallas.

In addition to taking off and landing vertically, the transport will cruise at 250 to 300 knots and will have a range of 200 to 300 nautical miles with up to 8,000 pounds payload. A full-scale mockup of the cargo compartment and cockpit, built at Ling-Temco-Vought, indicates the transport cargo hold would be 30 feet long and could carry either 8,000 pounds of freight or 32 fully equipped combat troops, in addition to a crew of three. The design features a loading ramp at the aft end.

All three companies of the team have considerable experience in the VTOL field.

Ryan is one of the world's outstanding pioneers in development of vertical and short take-off planes, having built two of the most successful test bed vehicles of this type.

They are the world's first jet VTOL, the Ryan X-13 Vertijet for the Air Force; and the Ryan VZ-3RY deflected slipstream Vertiplane, which has been successfully flown and is now in a new

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Tilt-Wing Transport

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phase of testing by NASA at Moffett Field, California.

Ling-Temco-Vought's Aeronautics Division, an experienced weapons systems manager, has developed VTOL background in a high speed turbofan VTOL concept known as ADAM. Hiller, a producer of light utility helicopters, developed the Air Force X-18 tilt-wing flying laboratory, world's largest V/STOL aircraft.

Added significance was attached to the tri-service military contract by N. E. Halaby, Administrator of the Federal Aviation Agency, at the recent annual meeting of the Army Aviation Association of America.

"The tri-service VTOL transport program leading to production of the first VTOL assault transport gives promise of producing a much-needed civil transport," Halaby said.

"We are looking forward to this aircraft. We shall be working with the services on it — advising on standards to meet certification, and advising on the problems of traffic control, landing areas and navigation requirements.

"It is also our plan to make a few of the advance models available to civil operators that they may make recommendations to be incorporated in the subsequent production models."

Interplanetary Navigation

(Continued from Page 3)

radio sources so as to make it possible to employ the Doppler shift of their absorption spectra in the solution of space navigation problems, especially in the case of midcourse guidance where active Doppler techniques cannot be used.

Three celestial radio sources are generally considered for the application of the passive Doppler technique, Cassiopeia A, Taurus A, and Sagittarius A. The closest of these sources, Taurus A, still lies at approximately 3600 light years from our solar system.

These sources have several important physical characteristics in common. As discrete radio sources, they each subtend an angle in the sky of approximately 6 minutes of arc. Their spectra may be observed both in emission and absorption. The absorption notch, caused by a hydrogen cloud between the observer and the radio source, is quite sharp and is the basis for their utility in space navigation. For example, the absorption notch of Cassiopeia A is 25 kc wide, while its radiation line is approximately 500 kc wide.

Two of these radio sources are above the celestial equator, Cassiopeia A at 58° 32′ declination and 23h 21m right ascension, Taurus A at 22° 00′ declination and 05h 31m right ascension. Sagittarius A, on the contrary, is below the celestial equator, at 28° 45′ declination and 17h 43m right ascension. This spacial distribution is particularly favorable for the determination of space vehicle velocity from three independent noncoplanar radial velocity measurements.

Cassiopeia A has the highest apparent intensity of the three sources and is the only source continuously visible by an observer on earth at a latitude of +40°, which is interesting for terrestrial airborne navigation. In the case of space navigation, which generally occurs approximately in the plane of the celestial equator, the three radio sources will be visible all the time. The spacecraft velocity, relative to any space coordinate system, will be derived from the combination of the three radial velocities relative to the three radio sources whose accurate position in space is known.

When the spacecraft arrives in the gravitation field of the planet of destination, Venus for example, the problem of planetary navigation arises once more. However, this time the planetary surface is unknown and invisible, and no help can be expected from ground stations. The exact size, rotation rate and axis of the planet also are unknown. With conventional radar techniques, the altitude and ground velocity can be determined and utilized to make the altitude and velocity corrections and remain in orbit around the planet. But, it appears that, with existing techniques, it would be impossible to determine the six orbital parameters of the satellite and its latitude and longitude with respect to any planetary reference.

Passive Doppler, optical techniques and radio aids offer approaches to solving the problems of midcourse guidance for interplanetary travel. However, at both ends of interplanetary travel, we are faced with the problem of planetary navigation. Navigation satellites in orbit about the base and target planets may aid in terminal navigation. Other techniques could include ground based radio aids, beacons or even self-contained navigation devices such as active Doppler and inertial systems. Considerable national effort will be required before optimum interplanetary navigation systems are available.

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ON THE COVER

Airstream from propellers on vertically tilted wing will provide thrust for vertical take-offs of new transport being developed by Ling-Temco-Vought, Hiller and Ryan.

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Doppler Navigation for Supersonic Transport

(Continued from Page 14)

trol information are found indirectly by computations or estimates. Ground speed, for instance, is determined by noting the time elapsed while transiting the known distance between two geographic points. This tells the pilot his average speed but not his PRESENT speed. The pilot flying a supersonic jet aircraft is going so fast that he not only needs to know his present position and speed, but he must also be able to predict his future position and speed. This and other flight control information must be automatically and continuously supplied to the supersonic pilot in order to stay within his authorized flight profile.

Examination of our present flight control instrumentation reveals that some equipments, whose performances are satisfactory at subsonic speeds, may provide unsatisfactory performances at supersonic speeds. Ryan continuous-wave Doppler navigation sets are designed and produced with a technical eye toward the flight control requirements of tomorrow's high performance aircraft.

A Doppler navigation set is a self-contained, active, airborne radar which automatically and continuously measures the velocity of the aircraft and computes such navigational information as cross track error, distance to destination, aircraft vertical and ground velocities, present position and speed, wind speed and wind heading angle through the use of standard, auxiliary inputs.

The Doppler radar offers the supersonic transport a navigation system which is free from dependence on ground stations. This permits flexible routing for economy since a maximum advantage of the wind may be taken. Upon take-off the set gives continuous velocity and position information to the pilot and continues until the aircraft lands.

During ascent and descent, the speed of a supersonic aircraft operating below 50,000 feet is relatively low, making the effects of the wind more severe than at the higher altitudes where the aircraft speed is higher. And, according to extended upper air observations, winds at lower altitudes are likely to have the largest velocities. Since take-off, climb and transition to supersonic flight occurs below 50,000 feet and covers a distance of about 250 miles, this places a portion of the flight of the supersonic craft in the operating altitude of present and future subsonic aircraft. Rigid control must be exercised over all traffic in the climb corridor or the results from flight lane deviation, however slight, could be disastrous. The advantages of the Doppler navigation set to this phase of flight are unlimited.

The pilot can note flight progress and establish time of arrival at the destination during the cruise portion of the flight as the Doppler radar provides accurate ground speed, ground track angle and position information. The radar can also furnish inputs to the autopilot such as cross track error for the case of automatic flight control. With true air speed and heading angle inputs, the Doppler set can calculate the wind speed and direction for use by the navigator and for ground use by other navigators in planning flights scheduled shortly for departure. The pilot immediately knows when to initiate the descent of the aircraft because the Doppler set continuously provides the distance to destination. During descent, accurate position and velocity information, including vertical velocity, is furnished by the radar as well as wind effect which, as in the climb phase, is more significant at lower speeds and altitudes than at cruise speeds and altitudes.

The presence of a Doppler radar set in the aircraft makes available a growth potential for a higher degree of automatic flight. The take-off and landing phases could be made automatically by a pre-programmed tape operating through the automatic pilot with Doppler radar furnishing velocity and position information as a part of the automatic control. Future supersonic flights could be completely automatic, from take-off through cruise and landing, by feeding a taped "master" through the automatic pilot while the Doppler set furnishes input information. 87 96

In summarizing the features which the Doppler navigation set offers the supersonic transport, safety, economy, flexible routing, reduced workload and growth potential, are the most prominent. From the safety standpoint, the pilot knowing his position at all times, will stay within his authorized airlane thus leading to low probability of an airborne collision. Economy of operation is gained through rigid control over the aircraft's flight profile with an accompanying minimum expenditure of fuel and a minimum loss of payload to fuel reserve. The Doppler radar set is completely self-contained thus eliminating navigational dependence on ground stations and permitting maximum freedom in the choice of routes. With the heading input, the velocity and present position of the aircraft is furnished automatically and continuously by the Doppler set. This relieves the navigator of some of his present duties, a condition needed for the increased flight speeds with corresponding reduced flight times of the supersonic transport. The outputs of the Doppler navigator offer considerable growth potential, particularly in the realm of automatic flight control.

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